Air

NATIONAL AIR POLLUTANT EMISSION TRENDS, PROCEDURES DOCUMENT, 1900-1996

Sources	PM-10	VOC
Point		
Area		
On-road		
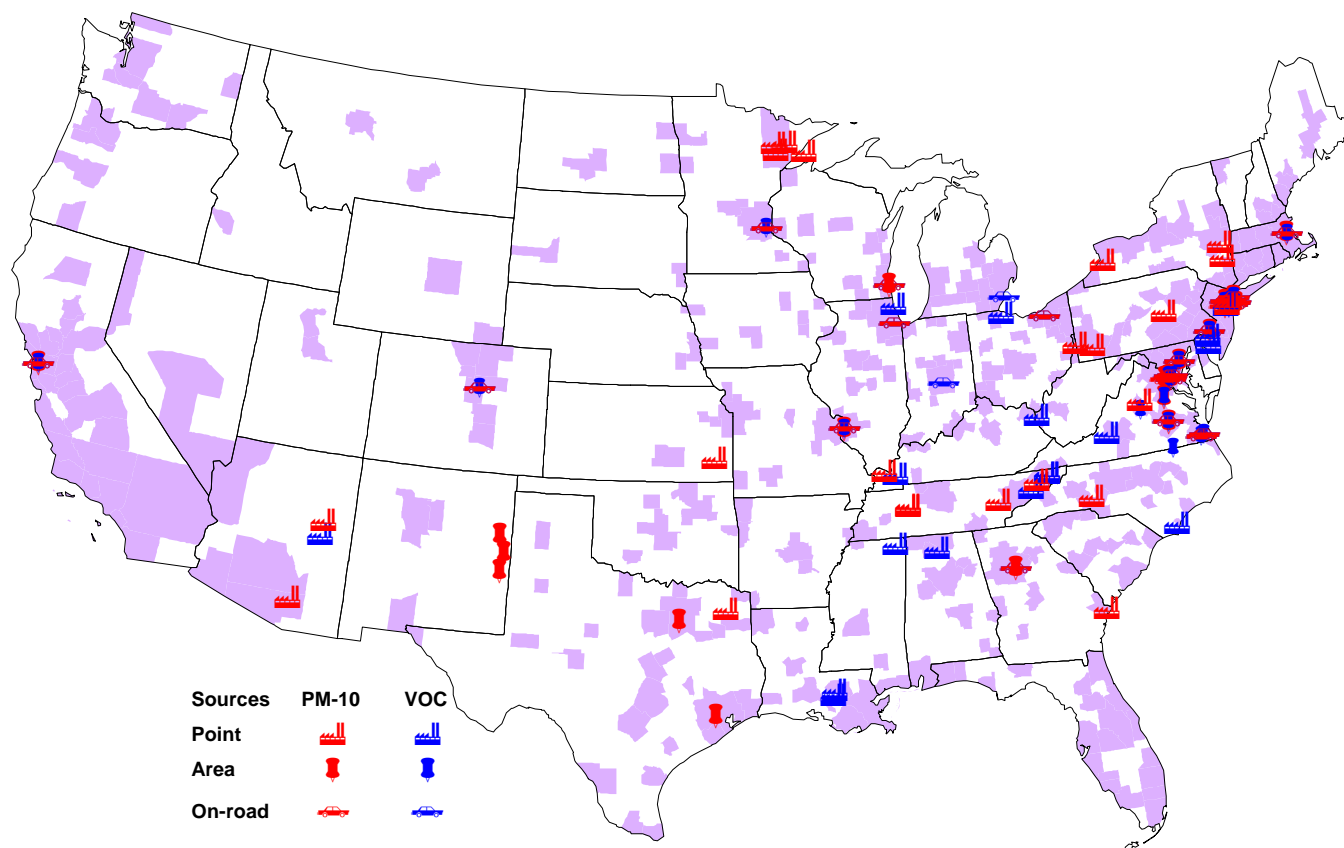
Top 25 Emitting Point, Area, and On-road Sources of PM-10 and VOC Emissions in 1996 by MSAs

CONTENTS

CONTENTS (continued)

CONTENTS (continued)

CONTENTS (continued)

CONTENTS (continued)

CONTENTS (continued)

CONTENTS (continued)

CONTENTS (continued)

CONTENTS (continued)

CONTENTS (continued)

CONTENTS (continued)

CONTENTS (continued)

CONTENTS (continued)

CONTENTS (continued)

CONTENTS (continued)

CONTENTS (continued)

CONTENTS (continued)

CONTENTS (continued)

CONTENTS (continued)

TABLES AND FIGURES

TABLES AND FIGURES (continued)

TABLES AND FIGURES (continued)

TABLES AND FIGURES (continued)

TABLES AND FIGURES (continued)

TABLES AND FIGURES (continued)

TABLES AND FIGURES (continued)

ACRONYMS AND ABBREVIATIONS

AADT	annual average daily traffic
AAMA	American Automotive Manufacturer's Association
AAR	Association of American Railroads
ACT	Alternative Control Technology
ADTV	average daily traffic volume
AIRS	Aerometric Information Retrieval System
AIRS/AMS	AIRS Area and Mobile Source Subsystem
AIRS/FS	AIRS Facility Subsystem
ARD	Acid Rain Division
ASTM	American Society for Testing and Materials
BEA	U.S. Department of Commerce, Bureau of Economic Analysis
BLS	U.S. Bureau of Labor Statistics
CAAA	Clean Air Act Amendments of 1990
CEM	continuous emissions monitor(ing)
CNOI	Census number of inhabitants
CO	carbon monoxide
CTG	Control Techniques Guidelines
CTIC	Conservation Information Technology Center
DOE	U.S. Department of Energy
DOT	Department of Transportation
DVMT	daily vehicle miles traveled
EIA	U.S. DOE, Energy Information Administration
EFIG	EPA, OAQPS, Emission Factors and Inventory Group
EG	earnings growth
EPA	U.S. Environmental Protection Agency
ERCAM/VOC	Emission Reductions and Cost Analysis Model for VOC
ESD	EPA, OAQPS, Emission Standards Division
ETS/CEM	Emissions Tracking System/Continuous Emissions Monitoring
FAA	Federal Aviation Adminstration
FCC	fluid catalytic cracking unit
FGD	flue gas desulfurization
FHWA	U.S. Federal Highway Adminstration
FID	Flame Ionization Detector
FREDS	Flexible Regional Emissions Data System
FTP	Federal Test Procedure
GCVTC	Grand Canyon Visibility Transport Commission
GT	gas turbines
HC	hydrocarbon
HCPREP	FREDS Hydrocarbon Preprocessor
HDV	heavy duty vehicle
hp	horsepower
HPMS	Highway Performance Monitoring System
IC	internal combustion (engine)
I/M	inspection and maintenance

ACRONYMS AND ABBREVIATIONS (continued)

LDT	light duty truck
LDV	light duty vehicle
LTO	landing and takeoff
MACT	maximum available control technology
MRI	Midwest Research Institute
MW	megawatts
NAA	nonattainment area
NADB	National Allowance Data Base
NAPAP	National Acid Precipitation Assessment Program
NEDS	National Emission Data System
NESHAP	National Emission Standards for Hazardous Air Pollutants
NET	National Emissions Trends (inventory)
NH_3	ammonia
NO_x	oxides of nitrogen
NPI	National Particulates Inventory
NSPS	New Source Performance Standards
OAQPS	EPA, Office of Air Quality Standards and Planning
OMS	EPA, Office of Mobile Sources
OSD	ozone season daily
OTAG	Ozone Transport Assessment Group
OTR	ozone transport region
Pb	lead
PCE	personal consumption expenditures
PM	particulate matter
PM-2.5	particulate matter less than 2.5 microns in diameter
PM-10	particulate matter less than 10 microns in diameter
ppm	parts per million
QA	quality assurance
QC	quality control
RACT	Reasonably Available Control Technology
RCRA	Resource Conservation and Recovery Act
ROM	Regional Oxidant Model
RVP	Reid vapor pressure
SCC	source classification code
SEDS	State Energy Data System
SIC	Standard Industrial Classification (code)
SIP	State Implementation Plan
SO_2	sulfur dioxide
SO_4	sulfates
SUPROXA	Super Regional Oxidant A
TOG	total organics
tpy	tons per year
TSDF	hazardous waste treatment, storage, and disposal facility
TSP	total suspended particulate matter

ACRONYMS AND ABBREVIATIONS (continued)

USDA   U.S. Department of Agriculture
USFS   USDA Forest Service
VMT   vehicle miles traveled
VOC   volatile organic compound(s)

SECTION 1.0
INTRODUCTION

The Emission Factors and Inventory Group (EFIG) of the U.S. Environmental Protection Agency (EPA) is responsible for compiling and maintaining national emission data for the criteria pollutants. To that end, EFIG produces estimates of the annual national air pollutant emissions for six major pollutants: carbon monoxide (CO), nitrogen oxides (NO_x), lead (Pb), particulate matter less than 10 microns (PM-10), sulfur dioxide (SO_2), and volatile organic compounds (VOC). In addition, total particulate matter (TSP) has been estimated in the past. For the years 1990-1996, particulate matter less than 2.5 microns (PM-2.5) and ammonia (NH_3) have also been estimated. These estimates are published annually in two EPA reports and are entitled for 1997, "National Air Pollutant Emission Trends, 1900-1996,"[1] and "National Air Quality and Emission Trends Report, 1996."[2] Collectively, these are known as the *Trends* Reports.

The 1997 *Trends* Procedures Document is an accompanying document designed to describe the methodology and procedures used to create the emission estimates presented in the 1997 *Trends* Reports. The emission estimating methodologies fall into five major categories: 1900-1939 Methodology, 1940-1984 Methodology, 1985-1989 Methodology, 1990-1996 Methodology, and 1997-2010 Methodology. The methodology used to make specific estimates depends on the pollutant and the time period. Table 1-1 presents a detailed characterization of the emission estimates created using each of these five methodologies and the section of this report that describes the methodology.

In general, the SO_2, NO_x, and VOC emissions for the time period before 1940 were using the 1900-1939 methodology. The emissions of no other pollutants were estimated for these years.

The 1940-1984 methodology was originally developed specifically to make the emission estimates for all years and pollutants presented in the *Trends* Reports. For the 1997 *Trends* report, this methodology was generally used to estimate the emissions for the years from 1940 to 1984. In addition to SO_2, NO_x, and VOC emissions, the emissions of CO, Pb, PM-10, and TSP are estimated by this methodology.

The emissions for the years from 1985 to 1989 were estimated by the methodology underlying a new emission inventory, the Interim Inventory.[3] This methodology was applied to the emission estimates for all pollutants, except Pb and TSP. The emissions of these pollutants are estimated using the 1940-1984 methodology. (TSP estimates were last developed for the 1992 emissions. Currently there is no plan to estimate TSP emissions in the future since the current National Air Quality Standards for particulate matter are for the size 10 microns or less.)

The emissions for the year 1990 are based on State-submitted data. The 1991-1996 emissions for non-utility point and area sources are based on economic growth [Bureau of Economic Analysis (BEA) or State Energy Data System (SEDS)] data and the Clean Air Act Amendments of 1990 (CAAA) controls. The remaining sources were estimated using modifications/updates to the Interim Inventory Methodology.

For each methodology, the procedures used to estimate the emissions are described by the source category divisions most appropriate for that methodology. For a given source category, the estimating procedure is described for all pollutants collectively, unless differences exist in the methods used for different pollutants. In this case, the methods used for each pollutant are described separately. Because of the unique nature of the methodology used to estimate the lead emissions, this methodology is described in section 5. This allows each section of the manual to be used independently.

Section 6 presents the methodology used to develop the emission projections for the years 1999, 2000, 2002, 2005, 2007, 2008, and 2010.

Emission estimates presented in the 1997 *Trends* Reports are categorized using the Tier structure. Emissions derived by the 1900-1939 methodology are presented by the Tier I categories. All other emissions appear by the Tier III categories. Because the methodologies are not necessarily described by these Tier categories, a description of the correspondence between the source categories used to describe the estimating methodology and the Tier structure is included in each section of this document.

This document is best used as a reference for those personnel who already have some familiarity with the trends report production process or for a technical person inquiring about the origins of the estimates. Some details of procedures are vaguely or inadequately defined, since getting such details down on paper and keeping the document current, is a real challenge. A new person who takes over responsibility for this work will in general need help from an experienced person.

In the past, the emission estimates presented in the *Trends* reports would change from one year to the next based on the development of new information, data, or methodologies used to estimate the emissions. These changes were applied not only to the most recent year, but to all or some of the preceding years. As of 1997, no such changes are planned to be made to the emissions for the years prior to 1985. Therefore, the methodologies and reference presented in this document for the determination of the emission for these years will not change. Updates may be made, however, to the emissions for the years 1985 to the current year of the report. Any changes in the data or methodologies used to estimate the emissions for this time period will be documented in yearly addenda to this procedures document.

1.1 REFERENCES

1. *National Air Pollutant Emission Trends, 1900-1996*. EPA-454/R-97-011. U.S. Environmental Protection Agency, Research Triangle Park, NC. December 1997.

2. *National Air Quality Emissions Trends Report, 1996*. U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1997.

3. *Regional Interim Emission Inventories (1987-1991), Volume I: Development Methodologies*. EPA-454/R-93-021a. Source Receptor Analysis Branch, U.S. Environmental Protection Agency, Research Triangle Park, NC. May 1993.

Table 1-1. Estimating Methods Used in the 1997 *Trends* Report

Tier Category	Time Period	Pollutant(s)	Methodology	Section
Fuel Combustion - Electric Utilities Fuel Combustion - Industrial Fuel Combustion - Other Chemical & Allied Product Mfg. Metals Processing Petroleum & Related Industries Other Industrial Processes Solvent Utilization Storage & Transport Waste Disposal & Recycling Natural Sources Miscellaneous	1900-1969, excluding 1940, 1950, and 1960	VOC, SO_2, and NO_x	1900-1939 Methodology	2
	1940, 1950, and 1960 and 1970 through 1984	VOC, SO_2, NO_x, CO, and PM-10	1940-1984 Methodology	3
		Pb	Lead Methodology	5
	1985 through 1989 and 1990 through 1996	VOC, SO_2, NO_x, CO, and PM-10	1985-1989 Methodology	4
		VOC, SO_2, NO_x, CO, PM-10, PM-2.5, and NH_3	1990-1996 Methodology	4
		Pb	Lead Methodology	5
	1999, 2000, 2002, 2005, 2007, 2008, 2010	VOC, SO_2, NO_x, CO, and PM-10	Projection Methodology	6
On-road Vehicles Non-road Sources	1900-1939	VOC, SO_2, NO_x	1900-1939 Methodology	2
	1940 through 1969	VOC, SO_2, NO_x, CO, and PM-10	1940-1984 Methodology	3
		Pb	Lead Methodology	5
	1970 through 1993	VOC, SO_2, NO_x, CO, and PM-10	1985-1993 Methodology	4
		PM-2.5 and NH_3	1990-1996 Methodology	4
		Pb	Lead Methodology	5
	1999, 2000, 2002, 2005, 2007, 2008, 2010	VOC, SO_2, NO_x, CO, and PM-10	Projection Methodology	6

NOTE(S): SO_2, VOC, and NO_x estimated 1900-1996.
CO, PM-10 estimated 1940-1996.
Lead estimated 1970-1996.
PM-10 fugitive Dust estimated 1985-1996.
PM-2.5 and NH_3 estimated 1990-1996.

Procedures Document for 1900-1996   1-3   Introduction

SECTION 2.0
1900 - 1939 METHODOLOGY

The SO$_2$, NO$_x$, and VOC emission estimates presented in the 1997 *Trends* report for the years 1900 through 1969, with the exception of the years 1940, 1950, and 1960,[1] were taken from two reports on historic emissions. The first contained SO$_2$ and NO$_x$ emissions for the years between 1900 and 1980.[1] The VOC emissions for the years between 1900 and 1985 were contained in the second.[2] A summary of the methodologies used to estimate these emissions is presented in this document. This summary includes the basic assumptions, categorization, and calculations used to estimate these emissions. The two reports[1,2] provide a more detailed discussion of the methodologies used to estimate these emissions.

2.1 DESCRIPTION OF EMISSION ESTIMATION METHODOLOGIES FOR SO$_2$ AND NO$_x$

A methodology for estimating historic SO$_2$ and NO$_x$ emissions was developed prior to the 1940 - 1984 methodology and served as the predecessor to that methodology. These historic emissions were prepared for the years 1900 to 1980. Of these historic estimates, the 1997 *Trends* report presented the emissions for the years 1900 through 1969, except for the years 1940, 1950, and 1960.[a] The general methodologies for producing these emissions are described in this document along with specific information concerning the emissions for the years from 1900 through 1970.

The emissions were categorized based on the sources of the emissions. Each source category included specific processes which generate emissions such as the combustion of coal by railroad locomotives. The general methodology for estimating emissions was based on two factors: (1) the activity indicator which represents the activity of each process (e.g. the quantity of coal consumed by railroad locomotives) and (2) the emission factor which represents the quantity of emissions produced by the process per unit of process activity (e.g. the pounds of SO$_2$ produced for every ton of coal burned by a locomotive). Table 2-1 lists the source categories, along with the activity indicators and a description of the processes included in each category.

2.1.1 State-Level Estimates

The state-level SO$_2$ and NO$_x$ emissions were produced for every fifth year beginning in 1900 and ending in 1970. The methodologies used to estimate the state-level emissions fall into three general groups. These groups are: (1) emissions from the combustion of fuels for heat and power, except by on-road vehicles, (2) emissions from the combustion of fuel for transportation by on-road vehicles, and (3) emissions from material processing, manufacturing, miscellaneous combustion, and miscellaneous burning. The three general methodologies used to estimate the emissions are described individually in the following sections.

---

[1] The emissions for the years 1940, 1950, and 1960 were estimated using the 1940-1984 methodology. This methodology is described in section 3.0 of this document.

2.1.2   Emissions from Fuel Combustion, Excluding On-road Vehicles

The source categories representing emissions produced by burning a fuel to generate heat or power are: electric utilities, industrial boilers, commercial and residential fuel uses, all uses of anthracite coal (as a fuel), all uses of wood (as a fuel), railroads, vessels, and non-road diesel engines. The emissions from each source category were further categorized by the fuel type (e.g., emissions from railroad were estimated for each of the two fuels burned by locomotives: coal and oil). The emissions from each source category and fuel type were determined using three pieces of information: (1) a fuel use indicator, (2) a fuel sulfur content (necessary to estimate SO_2 emissions only), and (3) an emission factor expressing the amount of SO_2 or NO_x produced by a given amount of fuel burned.

The primary fuel use indicator used was the state-level fuel consumption for a specific source and fuel type. If such data were unavailable, then a state-level fuel use indicator such as fuel demand, distribution, sales, or deliveries was used. Prior to 1940, state-level data were often unavailable; in these cases, a national fuel use indicator was used, if available. The national indicator was apportioned to the states using the same state/national ratios established for the earliest year having available state-level data. There were combinations of fuel types and source categories for which no fuel use indicators were available over specific time periods. For those cases listed in Table 2-2, emission estimates at the state level were not estimated.

The emission factor provided the ratio between the quantity of fuel consumed and the uncontrolled amount of SO_2 or NO_x emitted. The emission factors used to estimate the historic emissions were derived from those contained in AP-42, up to and including Supplement 14.[3] Emission factors representing a given source category, fuel type, and pollutant were weighted averages of the AP-42 emission factors representing specific processes. The weighting factors were the quantities of the specific fuel type consumed by each of the processes. These national emission factors were applied to all state-level fuel use data for all years.

In order to estimate SO_2 emissions, the sulfur content of the fuel burned was required. In 1970, the sulfur content was based on reports from individual plants. State average sulfur content was used for coal in 1965 and for other fuels in 1955. For the 1955 estimates, sulfur contents for coal were estimated for each state based on coal quality, quantity, and distribution. The emissions for all years prior to 1955 were estimated using the 1955 sulfur content data for all fuels.

The state-level emissions for SO_2 and NO_x were calculated for every fifth year between 1900 and 1970 using the general equations given below. Equations 2.1-1 and 2.1-2 were used for all fuel combustion sources.

$$SO_2 \ emissions_{i, j, k} \ = \ FC_{i, j, k} \ \times \ (EF_{j, SO_2} \times S_{i, j, k}) \qquad \text{(Eq. 2.1-1)}$$

$$NO_X \ emissions_{i, j, k} \ = \ FC_{i, j, k} \ \times \ EF_{j, NO_x} \qquad \text{(Eq. 2.1-2)}$$

where: FC =   fuel consumption   i   =   year
           EF =   emission factor   j   =   source category /fuel type
           S   =   sulfur content   k   =   state

2.1.3   Emissions from Fuel Combustion by On-road Vehicles

Emissions produced by on-road vehicles were divided into two subcategories: emissions from gasoline-powered vehicles and emissions from diesel-powered vehicles. Emissions were made estimated based on three pieces of information: gasoline or diesel fuel consumption, fuel efficiency (for gasoline only), and emission factor. In 1970, vehicle miles traveled (VMT) data became available and was used in place of the state-level fuel consumption and fuel efficiency. The fuel efficiency factor was needed to correlate the amount of gasoline consumed to the average number of miles traveled. A national average miles per gallon was estimated for every fifth year between 1965 and 1935. A constant fuel efficiency was used for all years prior to 1935.

The emission factors for estimating controlled emissions from gasoline-powered vehicles were expressed in terms of the amount of SO_2 or NO_x emitted for every mile traveled. State-specific emission factors were obtained from the MOBILE2 emission factor model[4] for the years 1950 though 1970. The factors calculated for 1950 were used for all preceding years. The factors for NO_x emissions were derived to represent two distinct road types: urban and rural.

The emission factors for estimating controlled emissions from diesel-powered vehicles were expressed in term of the amount of SO_2 and NO_x emitted for every gallon of diesel fuel consumed. Unlike the emission factors for gasoline-powered vehicles, those used for diesel-powered vehicles were national and not year-specific. No fuel efficiency was required to estimate the emissions from this vehicle type.

The SO_2 and NO_x emission estimates from on-road vehicles for the years prior to 1970 were produced using Equation 2.1-3. Equation 2.1-4 was used to produce the emission estimates for 1970.

$$\textit{On-road Vehicle Emissions}_{i,\,j,\,k} \;=\; (FC_{i,\,k} \times FE_i) \;\times\; EF_{i,\,j,\,k} \qquad \text{(Eq. 2.1-3)}$$

$$\textit{On-road Vehicle Emissions}_{1970,\,j,\,k} \;=\; VMT_{1970,\,j,\,k} \times EF_{1970,\,j,\,k} \qquad \text{(Eq. 2.1-4)}$$

where: FC   =   fuel consumption
           FE   =   fuel efficiency (gasoline-powered vehicles only)
           EF   =   emission factor
           i   =   year
           j   = SO_2 or NO_x
           k   =   state
           VMT =   vehicle miles traveled (1970 estimates only)

2.1.4 Emissions from Material Processing, Manufacturing, Miscellaneous Combustion, and Miscellaneous Burning

The source categories producing emissions as the result of material processing, manufacturing, miscellaneous combustion, and miscellaneous burning were: coke plants (combustion stacks), smelters, cement plants, wildfires, miscellaneous industrial processes, and miscellaneous other processes. With the exception of the two miscellaneous categories, the emissions were generally estimated from an activity indicator and an emission factor. The activity indicator specified the industrial output of the process or, in the case of the wildfire category, the area burned. The emission factors were derived from AP-42.[3] The general equation used to calculate the emissions for both pollutants is shown in Equation 2.1-5

$$E_{i, j, k, l} \ = \ A_{i, j, k, l} \times EF_{i, j, k, l} \qquad \text{(Eq. 2.1-5)}$$

where:

E	=	emission estimate	i	=	year
A	=	activity indicator	j	=	SO_2 or NO_x
EF	=	emission factor	k	=	state
			l	=	source category

Because of the diverse nature of this group, specific details of the methodologies used to calculate the emissions will be discussed for each category individually.

2.1.4.1 Coke Plants

The methodology used to estimate the uncontrolled emissions produced from the combustion stacks of coke plants was similar that used for coal combustion. In place of the amount of coal burned, these estimates were based on the amount of coal charged into the coke ovens. The SO_2 and NO_x emissions were estimated using Equations 2.1-1 and 2.1-2, respectively, with the emission factors, the state-level coal sulfur contents, and the state-level quantities of coal charged. This methodology accounts for only about 67 percent of the total SO_2 emitted by coke plants. The remaining 33 percent of the emissions were passed to the coke oven gas and were emitted latter in the steel manufacturing process and were categorized with miscellaneous industrial processes.

2.1.4.2 Smelters

The primary smelters category consisted of copper, lead, and zinc smelters. The copper smelters predominantly emitted SO_2 and only small amounts of NO_x, while the lead and zinc smelters emitted only SO_2. The methodology used to estimate the emissions from smelters varied according to the availability of pertinent data.

For the years between 1950 and 1970, the emissions from copper smelters from all but the major producing states were estimated using the state-level amounts of copper ore concentrate produced and a national emission factor. Emissions from the major copper smelter states were obtained from a visibility study.[5] After 1960, SO_2 emissions from lead and zinc smelters were based on information obtained from a study of individual smelters.[6]

For copper smelters before 1955 and for lead and zinc smelters before 1965, a different methodology was employed. The state-level quantity of ore smelted was estimated using the amount of recoverable metal produced by the mines in a given state. It was assumed that any ore mined in a given state was smelted in the same state. If the given state was known to have no smelters, then it was assumed that the ore was smelted in the nearest state having a smelter. A national SO_2 emission factor was used to convert the quantity of recoverable metal to the uncontrolled quantity of SO_2 produced. A national NO_x emission factor was used to calculate the NO_x produced by the copper smelters.

The controlled SO_2 emissions were determined by subtracting the amount of SO_2 recovered during the production of sulfuric acid. Because only national by-product sulfuric acid production data was available, it was assumed that the amount of SO_2 recovered for each state was proportional to the smelter output for that state.

2.1.4.3   Cement Plants

SO_2 and NO_x emissions from cement plants were produced by both the minerals processed in the kiln and the combustion of fuels to heat the kiln. The industrial activity indicator used to estimates the emissions was the total annual production of portland cement by state. State-level SO_2 emission factors were the sum of the emission factors for the mineral sources, the combustion of coal, and the combustion of oil. The NO_x emission factors were average national factors. The emission factors calculated for 1955 were used to determine the emission estimates for all preceding years.

2.1.4.4   Wildfires

Wildfire emissions were defined as emissions from the combustion of vegetation in any uncontrolled fire. The activity indicator for this category was the total area burned annually in each state. This information was available for most states by 1925 and for all states by 1940. Prior to 1925, the acreage burned was assumed to be equal to the acreage burned in 1925. State-level emission factors reflected variations in vegetation (e.g. woodlands as compared to grasslands).

2.1.4.5   Miscellaneous Industrial Processes

A list of the industrial processes included in this category is given in Table 2-3. The SO_2 and NO_x emissions for this source category were determined by backcasting 1980 state-level emissions obtained from the National Emission Data System (NEDS)[7] using national growth factors. The yearly national growth factors for the years after 1940 were defined as the ratio between the national emissions for the specific year and the 1980 national emissions. Growth factors for the earlier years were based on national population. Equation 2.1-6 was used to estimate the emissions for this category.

$$SE_i = SE_{1980} \times \frac{NE_i}{NE_{1980}}$$ (Eq. 2.1-6)

where: SE = SO_2 or NO_x state emission estimate
         NE = SO_2 or NO_x national emission estimate
         i = year

2.1.4.6 Miscellaneous Other Processes

Table 2-3 contains a list of the processes included in this category. The methodology used to estimate the emissions for this category is similar to that used above for the industrial processes. For this category, national emissions were available from the 1980 NEDS[7] and the emissions were apportioned to the states based on 1980 population data. State-level growth factors for a given year were applied to the 1980 state-level emissions to backcast the emissions for that given year. The growth factors for each state were calculated as the ratio between the estimated state population for that year and the 1980 state population. Equation 2.1-7 was used to calculate the SO_2 and NO_x emissions for this source category.

$$SE_i = SE_{1980} \times \frac{S_i}{S_{1980}} \qquad \text{(Eq. 2.1-7)}$$

where: SE = SO_2 or NO_x state emissions
 S = state population
 i = year

State population data for every tenth year was obtained from population census data. For the intervening years, the state populations were estimated using Equation 2.1-8.

$$S_{i+j} = (S_{i+10} - S_i)\, \frac{N_{i+j} - N_i}{N_{i+10} - N_i} + S_i \qquad \text{(Eq. 2.1-8)}$$

where: S = state population
 N = national population
 i = census year (1900, 1910, …, 1970)
 j = integer 5 representing every fifth year

2.1.5   Yearly State-Level Emissions

The SO_2 and NO_x emissions were calculated every fifth year from 1900 to 1970 as described in the preceding section. For the source categories representing emissions produced by the combustion of fuels, the emissions for each intervening year were estimated by equating the changes in national fuel consumption to the changes in the state-level emissions. Consumption data for the following fuels were used: bituminous coal, anthracite coal, distillate and residual oils (combined), natural gas, wood, and gasoline and diesel fuel (combined). The interpolated state-level emissions for each pollutant were calculated using Equation 2.1-9.

$$SE_{i+j+1} = (SE_{i+5} - SE_{i+j}) \times \frac{NF_{i+j+1} - NF_{i+j}}{NF_{i+5} - NF_{i+j}} + SE_{i+j} \qquad \text{(Eq. 2.1-9)}$$

where: SE   = SO_2 or NO_x state emissions by source category and fuel type
         NF   =   national fuel consumption data corresponding to source category and fuel type
         i   =   study year (i.e., 1900, 1905, …, 1970)
         j   =   integer representing the intervening year (0, 1, 2, or 3)

For the following fuel types and years, the national fuel consumption changed radically and, therefore, was not used to estimate the yearly emissions: bituminous coal for the years 1912 and 1913 and natural gas for the years 1931, 1932, and 1933. In these cases, the yearly SO_2 and NO_x emissions were determined by a linear interpolation according to Equation 2.1-10.

$$SE_{i+j} = SE_i + ((SE_{i+5} - SE_i) \times j/5) \qquad \text{(Eq. 2.1-10)}$$

where: SE   = SO_2 or NO_x state emissions by source category
         i   =   study year (i.e., 1900, 1905, …, 1970)
         j   =   integer representing the intervening year (1, 2, 3, or 4)

For the source categories in which the emissions were not based on fuel consumption (i.e., smelters, cement plants, wildfire, miscellaneous industrial processes, and miscellaneous other sources), the yearly emissions were also calculated by a linear interpolation as given in Equation 2.1-10.

2.1.6   Allocation of Emission Estimates to Tier I Categories

The emission estimates for the years 1900 through 1969 (excluding 1940, 1950, and 1960) were presented graphically in the 1997 *Trends* report by Tier I categories. These categories were not the same as those used in the original calculation of the emissions as described in the preceding sections. A correspondence was developed between the original historic emission categories and the Tier I categories.

The historic emissions were summed into five general categories as shown in Table 2-4. These categories were then mapped to the Tier I categories as shown in Table 2-5. There was a one-to-one correspondence between the major historic categories and the Tier I categories for three Tier I categories: (1) Fuel Combustion - Electric Utilities, (2) Fuel Combustion - Other, and (3) On-road Vehicles. The historic emissions were assumed to be zero for two Tier I categories: (1) Solvent Utilization and (2) Storage and Transport.

The emissions from the other two historic categories were allocated to the corresponding Tier I categories based on the distribution of emissions for a specific base year. The Industrial historic category was correlated to five Tier I categories: Fuel Combustion - Industrial (02), Chemical and Allied Products Manufacturing (04), Metals Processing (05), Petroleum and Related Industries (06), and Other Industrial Processes (07). To distribute the emissions from the Industrial historic category to a specific Tier I category, a ratio between the base year emissions for the specific Tier I category and the sum of the base year emissions for all five of the Tier I categories correlated to the Industrial historic category was used. The same procedure was used to distribute the emissions from the Other historic category which

correlates to three Tier I categories: Waste Disposal and Recycling (10), Non-road Sources (12), and Miscellaneous (14). The base year was 1940, 1950, or 1960, depending on the year for which the emissions were being distributed. The emissions for these base years were developed using the 1940-1984 methodology (see section 3.0) and were distributed to the Tier I categories. The method for distributing emissions to Tier I categories is summarized in Equation 2.1-11.

$$E_{Tier1,\,i} \;=\; E_{Historic,\,i} \times \left[\frac{E_{Tier1}}{\sum \left(E_{Tier1\ categories\ corresponding\ to\ Historic\ category} \right)} \right]_B \qquad \text{(Eq. 2.1-11)}$$

where:
E = SO_2 or NO_x emissions
i = historic emissions year (1900, 1905, …, 1935, 1945, 1955, 1965)
B = base year: 1940 (for historic years 1900 to 1935 and 1945)
1950 (for historic year 1955)
1960 (for historic year 1965)
Historic = Industrial historic category or Other historic category
Tier I = categories 02, 04, 05, 06, or 07 or categories 10, 12, or 14
Tier I categories corresponding to Historic category
= 02 + 04 + 05 + 06 + 07 (for Industrial historic category)
10 + 12 + 14 (for Other historic category)

For the intervening years, the distribution of the emissions to the Tier I categories was made from the historic emission estimates totaled over all categories. The average percentage distribution of the total emissions to a specific Tier I category was calculated for every 6-year period (e.g., 1900 to 1905, 1925 to 1930). The percentage distribution was applied to each intervening year within the 6-year period. Equation 2.1-12 illustrates this method.

$$E_{Tier1,\,i+j} \;=\; E_{Total,\,i+j} \times \left[\frac{E_{Tier1,\,i} \;+\; E_{Tier1,\,i+5}}{E_{Total,\,i} \;+\; E_{Total,\,i+5}} \right] \qquad \text{(Eq. 2.1-12)}$$

where:
E = SO_2 or NO_x emissions
i = every fifth year between 1900 and 1965
j = integer representing the intervening year (1, 2, 3, or 4)
Tier I = Tier I category
Total = totaled over all historic categories

2.2 DESCRIPTION OF EMISSION ESTIMATION METHODOLOGY FOR VOC

The basic methodology for estimating the VOC emissions was a top-down method using national activity indicators and national emission factors. This was substantially different from the methodology used to produce the SO_2 and NO_x emission estimates where more detailed state-level data was used

wherever possible. The VOC emissions were divided into five broad source categories, each of which is subdivided into more refined subcategories. These categories and corresponding subcategories are presented in Table 2-6. For these emission estimates, the term national referred to the contiguous United States.

2.2.1   National VOC Emission Estimates (every 5 years between 1900 and 1970)

National emissions for the years 1940, 1950, 1960, 1965 and 1970 were obtained directly from the 1985 *Trends* report.[8] These data, along with that for 1975, 1980, and 1985, were used to estimates the emissions for every fifth year between 1900 and 1935 and the years 1945 and 1955. The methodology described below pertains to these years.

The two data values required to estimate the national annual VOC emissions for each source subcategory were: (1) national annual activity indicators and (2) national annual emission factors. The national activity indicators for each source subcategory for the years 1955, 1945 and every fifth year between 1900 and 1935 were obtained from a variety of sources.   In cases where the activity indicators contained data from Alaska, Hawaii, or the U.S. territories, the activity indicators for areas outside the contiguous United States were subtracted from the total activity indicators. This resulted in the national (i.e., contiguous United States) activity indicator.

The development of the national annual emission factors required two steps: (1) back-calculation of the emission factors for the years 1940, 1950, and every fifth year between 1960 and 1985 and (2) extrapolation of these national emission factors to the years under study. In order to back-calculate emission factors, activity indicators and emissions were required. National emissions were obtained for the years 1940, 1950, and every fifth year between 1960 and 1985 from the 1985 *Trends* report.[8] These emissions were disaggregated into the source subcategories given in Table 2-6. The *Trends* report was also the source of the national activity indicators for all subcategories for the same years. For each year and source subcategory, a national emission factor was calculated using Equation 2.2-1.

$$NEF_{i,j} \;=\; \frac{NE_{i,j}}{NA_{i,j}} \qquad\qquad \text{(Eq. 2.2-1)}$$

where: NEF   =   national emission factor   i   =   year
          NE   =   national emissions   j   =   source subcategory
          NA   =   national activity indicator

For some source subcategories, these national emission factors were unchanged over time. In those cases, the constant emission factor was used in calculating the emissions for all years. For source categories where the national emission factors changed between the years 1940 through 1985, the emission factors for the years before 1940 and for the years 1945 and 1955 were extrapolated from the back-calculated data.

The national VOC emissions for the years 1945 and 1955, and for every fifth year between 1900 and 1935, were calculated for each subcategory using Equation 2.2-2.

$$NE_{i,j} \;=\; NEF_{i,j} \times NA_{i,j} \qquad\qquad \text{(Eq. 2.2-2)}$$

where: NEF = national emission factor   i = year
        NE   = national emission estimate   j = source subcategory
        NA   = national activity indicator

2.2.2   Yearly National Emissions

The national emissions for every fifth year between 1900 and 1970 were used to interpolate the national emissions for the intervening years. The activity indicators used to the interpolate the emissions for each subcategory or group of subcategories are presented in Table 2-6. The national activity data for each year were obtained from the report of historic SO_2 and NO_x emissions.[1] The national emissions for each of the intervening years were calculated by equating the yearly change in the national activity indicators to the yearly change in the national emissions. The national emissions were calculated according to Equation 2.2-3 when using fuel consumption indicators. For source categories where population was used as the activity indicators, the yearly emissions were calculated using a linear interpolation as shown in Equation 2.2-4.

$$NE_{i+j} \;=\; (NE_{i+5} - NE_{i+j-1}) \times \frac{NA_{i+j} - NA_{i+j-1}}{NA_{i+5} - NA_{i+j-1}} + NE_{i+j-1} \qquad\qquad \text{(Eq. 2.2-3)}$$

$$NE_{i+j} \;=\; NE_i + (NE_{i+5} - NE_i) \times j/5 \qquad\qquad \text{(Eq. 2.2-4)}$$

where: NE = national emissions by source subcategory
        NA = national activity by source category
        i = study year (1900, 1905,...,1970)
        j = integer representing intervening years (1, 2, 3, or 4)

2.2.3   Changes in Emissions

The emission factors for the source category External Fuel Combustion, subcategory Wood have been changed since the time the original report[2] was published. This adjustment of the erroneously high emission factors was based on more current information. The updated emission factors for the years 1900 through 1970 are presented in Table 2-7. No changes were made to the activity indicators for this subcategory. The emissions presented in the 1993 through the 1997 *Trends* reports for the years 1900 through 1969, excluding 1940, 1950, and 1960, were based on recalculated emissions for this subcategory using the adjusted emission factors. Therefore the values published in the original report differ from those presented in the most recent *Trends* reports.

2.2.4   Allocation of Emission Estimates to Tier I Categories

The emissions for the years 1900 through 1969 (excluding 1940, 1950, and 1960) were presented graphically in the 1997 *Trends* report by Tier I categories. These categories were not the same as those used in the original calculation of the emissions as described in the preceding sections. A correspondence was developed between the original historic emission categories and the Tier I categories.

The historic emissions determined by source subcategories were summed to the five major source categories described previously in Table 2-6. These categories were then mapped to the Tier I categories as shown in Table 2-8. There was only one major historic source category (Solid Waste) which corresponds directly to a Tier I category (Waste Disposal and Recycling). For all other Tier I categories, the distribution of the historic major source categories to the Tier I categories was accomplished by the same method described in section 2.1.6 for the SO_2 and NO_x emissions and summarized in Equations 2.1-11 and 2.1-12.

2.3 REFERENCES

1. *Historic Emission of Sulfur and Nitrogen Oxides in the United States from 1900 to 1980*. EPA-600/7-85-009a and b. U.S. Environmental Protection Agency, Cincinnati, OH. April 1985.

2. *Historic Emission of Volatile Organic Compounds in the United States from 1900 to 1985*. EPA-600/7-88-008a. U.S. Environmental Protection Agency, Cincinnati, OH. May 1988.

3. *Compilation of Air Pollutant Emission Factors, Third Edition, Supplements 1 through 14, AP-42*. NTIS PB-275525. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1977.

4. *Mobile Source Emission Factors*. EPA-400/9-78-005 (NITS PB295672/A17). U.S. Environmental Protection Agency, Washington, DC. March 1978.

5. M. Marians, J. Trijonis. *Empirical Studies of the Relationship Between Emissions and Visibility in the Southeast*. EPA-405/5-79-009 (NITS PB80-156136/A06). U.S. Environmental Protection Agency, Research Triangle Park, NC. 1979.

6. *Background Information for New Source Performance Standards: Primary Copper, Zinc and Lead Smelters, Volume 1: Proposed Standards*. EPA-450/2-74-002a (NITS PB237832). U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1974.

7. *National Emissions Report, National Emissions Data System (NEDS)*. EPA-450/4-83-022 (NITS PB84-121375/MF). U.S. Environmental Protection Agency, Research Triangle Park, NC. 1984.

8. *National Air Pollutant Emission Estimates, 1940-1985*. EPA-450/4-86-018. U.S. Environmental Protection Agency, Research Triangle Park, NC. January 1987.

Table 2-1. Historic NO$_x$ and SO$_2$ Emission Source Categories, Fuel Types, and Descriptions*

Source Category	Activity Indicator Consumption or Production	Description
Electric Utilities	Bituminous Coal, Residual and Distillate Oil, Natural Gas, and Wood (after 1945)	Power plants using coal, oil or gas to provide electricity for public consumption
Industrial Boilers	Bituminous Coal, Residual and Distillate Oil, Natural Gas and Wood (after 1945)	Manufacturing and mining facilities using fuel for heat, power and chemical feedstocks, and natural gas lease and plant operations
Commercial/Residential	Bituminous Coal, Residual and Distillate Oil, Natural Gas, and Wood (after 1945)	Nonmanufacturing enterprises using fuel for heat or power and agricultural, forestry, and fisheries facilities using natural gas. Private dwellings using fuel for heating, cooking, and other household uses
Anthracite Coal - all uses	Anthracite Coal	All facilities using anthracite coal as a fuel
Wood - all uses (1900 through 1945)	Wood	All facilities using wood as a fuel
Pipelines	Natural Gas	Internal combustion engines and turbines used to compress gas
On-road Vehicles	Gasoline and Diesel fuel	Automobiles, trucks, buses, and motorcycles using gasoline or diesel fuel for transportation
Railroads	Bituminous Coal and Distillate Oil	Trains, operated railroad equipment and other related operations
Coke Plants	Bituminous Coal	Furnace and merchant plants which produce coke
Smelters	Ore	Primary copper, lead, and zinc smelting facilities
Vessels	Residual and Distillate Oil	Commercial and private boats, including ocean going vessels
Non-road Diesel Engines	Diesel Fuel	engines used in construction, logging, and road building
Cement Plants	Portland Cement	Portland cement manufacturing plants
Wildfire	Area	Projected and unprotected forest land burned
Miscellaneous	Other	Industrial processes not included about and other miscellaneous anthropogenic sources

* Taken from Reference 1, Table 1 and Table 2.

Table 2-2. Historic NO$_x$ and SO$_2$ Emission Source Categories Not Estimated*

Source Categories	Range of Years
All Fuel Oil Burning	1900 to 1920
Natural Gas-fired Electric Utilities	1900 to 1915
Natural Gas-fired Industrial and Commercial/Residential Uses	1900 to 1920
Pipelines	1900 to 1945

* Taken from Reference 1, page 31.

Table 2-3. Processes Included in the Miscellaneous Source Category*

Miscellaneous Subcategory	Processes	Subprocesses
Industrial Processes	Pulp and paper	
	Petroleum Refineries	
	Iron and Steel Manufacture	
	Primary Aluminum	
	Secondary Lead	
	Glass Manufacture	
	Chemical Manufacture	sulfuric acid carbon black petrochemicals ammonia nitric acid TNT
Other Sources	Aircraft	
	Vessels	gasoline-powered coal-powered
	Miscellaneous off-highway gasoline-powered vehicles	
	Fuel combustion	LPG coke-oven gas bagasse
	Solid Waste Disposal	
	Agricultural Burning	
	Coal Refuse Burning	
	Prescribed Burning	

* Taken from Reference 1, Tables 10 and 11, page 31.

Table 2-4. Major Source Categories for SO$_2$ and NO$_x$ Historic Emissions

Major Source Categories	Source Categories (used in determination of emission estimates)
Electric Utilities	Electric Utilities: bituminous coal, residual oil, distillate oil, natural gas, and wood (after 1945)
Industrial	Industrial boilers: bituminous coal, residual oil, distillate oil, natural gas, and wood (after 1945) Pipelines Coke Plants Cement Plants
Commercial/Residential	Commercial/Residential: bituminous coal, residual oil, distillate oil, natural gas, and wood (after 1945)
On-road Vehicles	On-road Vehicles: gasoline and diesel
Other	Anthracite coal (all uses) Wood (all uses from 1900 to 1940) Railroads Smelters Vessels Wildfires Non-road diesel Miscellaneous

Table 2-5. Correlation between Tier I Categories and Historic Major Source Categories for SO$_2$ and NO$_x$ Emission Estimates

Tier I Categories		Historic Major Source Categories
Code	Name	
01	Fuel Combustion - Electric Utilities	Electric Utilities
02	Fuel Combustion - Industrial	Industrial
03	Fuel Combustion - Other	Commercial/Residential
04	Chemical and Allied Product Manufacturing	Industrial
05	Metals Processing	Industrial
06	Petroleum and Related Industries	Industrial
07	Other Industrial Processes	Industrial
08	Solvent Utilization	assumed zero
09	Storage and Transport	assumed zero
10	Waste disposal and Recycling	Other
11	On-road Vehicles	On-road Vehicles
12	Non-road Engines and Vehicles	Other
13	Miscellaneous	Other

Table 2-6. Source Categories and Activity Indicators for Historic VOC Emission Estimates*

Source Category	Estimates for Every Fifth Year from 1900 to 1970		Estimates for Intervening Years	
	Source Subcategory	Activity Indicators	Source Subcategories	Activity Indicators
TRANSPORTATION				
	On-road Vehicles	On-road Vehicle Gasoline plus Diesel Consumption	On-road Vehicles	Gasoline and Diesel Consumption
	Aircraft	Population	All Other Subcategories	Population
	Railroads			
	oil-fired	Railroad Oil Consumption		
	coal-fired	Railroad Oil Consumption		
	Vessels			
	oil-fired	Vessel Oil Consumption		
	coal-fired	Vessel Coal Consumption		
	Other Non-road Source Use	Non-road Fuel Use		
EXTERNAL FUEL COMBUSTION				
	Anthracite Coal	Anthracite Consumption	Anthracite Coal	Anthracite Consumption
	Bituminous Coal	Bituminous Consumption	Bituminous Coal	Bituminous Consumption
	Residual Oil	Residual Oil Consumption	Residual and Distillate Oil	Fuel Oil Consumption
	Distillate Oil	Distillate Oil Consumption		
	Natural Gas	Natural Gas Consumption	Natural Gas	Natural Gas Consumption
	Wood	Wood Consumption	Wood	Wood Consumption
	Coke and Other Fuels	Coke Production	Coke and Other Fuels	Population
INDUSTRIAL PROCESSES				
	Petrochemical Manufacture	Population	Petrochemical Manufacture	Population
	Petroleum Marketing		Petroleum Marketing	Gasoline and Diesel Consumption
	gasoline	On-road Vehicle Gasoline Consumption		
	other	Diesel plus Distillate Oil Consumption		

Table 2-6 (continued)

Source Category	Estimates for Every Fifth Year from 1900 to 1970		Estimates for Intervening Years	
	Source Subcategory	Activity Indicators	Source Subcategories	Activity Indicators
INDUSTRIAL PROCESSES (continued)				
	Surface Coating Operations	Population and Cement Production	Surface Coating Operations	Population
	Petroleum Refinery Process Operations	Crude Oil Run	All Other Subcategories	Crude Oil Consumption
	Petroleum Production			
	crude oil	Crude Oil Run		
	natural gas liquids	Crude Oil Run		
	Miscellaneous Industrial Processes	Population		
	Carbon Black Mfg.	VMT		
SOLID WASTE DISPOSAL				
	Incineration	Population	All Subcategories	Population
	Open Burning	Population		
MISCELLANEOUS OTHER SOURCES				
	Wildfire	Area Burned	All Subcategories	Population
	Prescribed Fires	State Land Area minus Wildfire Area		
	Other Burning	State Land Area minus Wildfire Area		
	Other Solvent Evaporation	Population		

* Taken from Reference 2, Tables 1 and 2, pages 5 and 9, respectively.

Table 2-7. Adjusted VOC Emission Factors for External Fuel Combustion, Wood

Year	Emission Factors (tons/1000 tons)
1900	15.28
1905	14.65
1910	14.01
1915	13.38
1920	12.74
1925	12.11
1930	11.47
1935	10.84
1940	10.21
1945	9.57
1950	8.94
1955	7.79
1960	6.65
1965	5.37
1970	4.10
1975	4.14
1980	5.24
1985	4.81
1990	5.15

Table 2-8. Correlation between Tier I Categories and Historic Major Source Categories for VOC Emission Estimates

Tier I Categories		Historic Major Source Categories
Code	**Name**	
01	Fuel Combustion - Electric Utilities	External Combustion
02	Fuel Combustion - Industrial	External Combustion
03	Fuel Combustion - Other	External Combustion
04	Chemical and Allied Product Manufacturing	Industrial Processes
05	Metals Processing	Industrial Processes
06	Petroleum and Related Industries	Industrial Processes
07	Other Industrial Processes	Industrial Processes
08	Solvent Utilization	Miscellaneous
09	Storage and Transport	Industrial Processes
10	Waste disposal and Recycling	Solid waste
11	On-road Vehicles	Transportation
12	Non-road Engines and Vehicles	Transportation
13	Miscellaneous	Miscellaneous

SECTION 3.0
1940 - 1984 METHODOLOGY

This methodology was used to estimate emissions for the majority of pollutants presented in the *Trends* report for the years 1940, 1950, 1960, and 1970 to 1984. For all source categories, excluding on-road vehicles and non-road engines and vehicles, this methodology was used to estimate the CO, NO_x, PM-10, SO_2, and VOC for these years. The TSP emissions for the years 1940, 1950, 1960, and 1970 to 1992 were estimated using this methodology. The lead emissions are explained in section 5.0. The emissions originating from on-road vehicles and non-road sources were estimated for the years 1940, 1950 and 1960 using this methodology. This section describes, in detail, the procedures used to estimate these emissions.

3.1 INTRODUCTION

The 1940-1984 methodology was based on a "top-down" approach where national information was used to create a national emission estimate. Emissions were estimated based on the source of the emissions and, in the case of combustion sources, the fuel type. National activity of a process producing emissions of interest was measured by the consumption of fuel, the throughput of raw materials, or some other production indicator. The emission factor was used to determine the amount of an individual pollutant emitted based on the activity of the process. In the case of PM-10, TSP, and SO_2 emissions, average fuel property values of ash and sulfur content were incorporated into the estimating procedure as part of the emission factor. The final element used to estimate emissions was the control efficiency which quantifies the amount of a pollutant not emitted due to the presence of control devices.

The overall procedure is outlined below:

INPUT DATA

```
┌─────────────────────────┐        ┌──────────────────────┐
│ Activity Indicators     │        │ Control Efficiency   │
│ Emission Factors        │        └──────────────────────┘
│ Fuel Property Values    │
└─────────────────────────┘
```

ESTIMATION ALGORITHM

(Uncontrolled Emissions - Controlled Emissions) / (Actual Emissions)

OUTPUT DATA

National Emissions of Criteria Pollutants
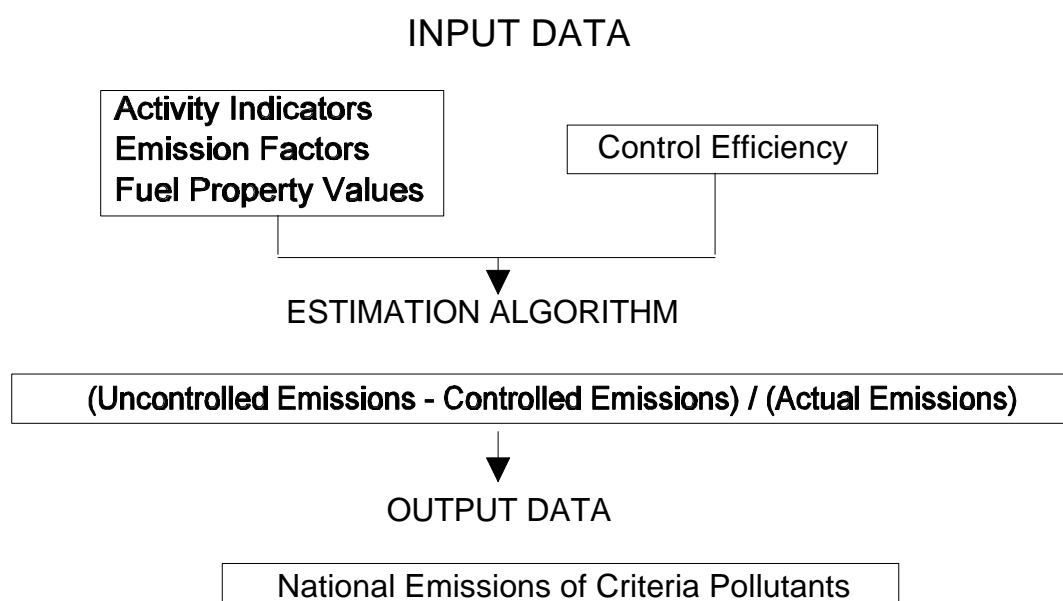
The emissions were presented in the 1997 *Trends* report by Tier categories, but in the 1940-1984 methodology, the emissions were estimated by a different set of source categories. In most cases, these source categories or subcategories were regrouped into the Tier categories. For several categories or subcategories, the emissions were apportioned to more than one Tier II category. The estimation procedures are presented in this section by the Tier II categories. Correspondence between these Tier II categories and the 1940-1984 methodology source categories are presented in Table 3.1-1. This correspondence between the categories is reiterated within the description of the procedures for each Tier II category.

3.1.1   General Procedure

Since it is impossible to measure the emissions of every historic source individually, a top-down estimating procedure is used. The emissions are calculated either for individual sources or for many sources combined, using indicators of emissions. Depending on the source category, these indicators may include fuel consumption or deliveries, VMT, tons of refuse burned, or raw material processed. When indicators are used, emission factors which relate quantity of emissions to the activity indicator are also used.

Emission factors are not necessarily precise indicators of emissions. They are quantitative estimates of the average rate of emissions from many sources combined. These factors are most valid when applied to a large number of sources. If their limitations are recognized, emission factors can be extremely useful tools for estimating national emissions. The calculations of the emissions were made according to the following general equation:

$$Emissions_{i, j, k} \;=\; A_{i, j} \times EF_{i, j, k} \times [1 - CE_{i, j, k}] \qquad \text{(Eq. 3.1-1)}$$

where:
A	=	activity
EF	=	emission factor
CE	=	control efficiency (fraction)
i	=	year
j	=	source category
k	=	pollutant

The SO_2 emission factor for sources where the emissions were based on fuel combustion included the sulfur content of the fuel. Emission factors for PM-10 and TSP included the ash content of the fuel for combustion sources. The VOC emission factors included a factor representing the reactive portion for a variety of source categories.

As an aid in the calculation of the emissions by the 1940-1984 Methodology, two Excel spreadsheets, collectively referred to as the *Trends* spreadsheets, were created for each year. An example is provided in Table 3.1-2. These spreadsheets were entitled TRENDSxx.XLS and MGTMPxx.XLS, where xx represents the year. The required data was entered into the TRENDSxx.XLS spreadsheet, after which the MGTMPxx.XLS spreadsheet was opened and the necessary calculations (those shown above) were made to estimate the national emissions. This procedure was designed to simplify the process of estimating emissions for a new year. By using the TRENDSxx.XLS spreadsheet from the previous year

as a template, the spreadsheet for the new year was created by editing only the data requiring updating. These spreadsheets now serve as a record of the calculations used to estimate the national emissions for CO, NO_x, PM-10, SO_2, TSP, and VOC for the years 1940, 1950, 1960 and the years 1970 through 1984.

The calculations employed within the TRENDSxx.XLS spreadsheets required the use of specific units for the activity indicators and the emission factors. These required units are specified in the descriptions of the procedures for each of the Tier II categories. In general, the units for activity indicators were short tons for solids, gallons for liquids, and cubic feet for gases. Emission factors were expressed in units of metric pounds of pollutant per unit consumption or throughput. Control efficiency was expressed as a dimensionless decimal fraction. By using these units, emissions calculated within the spreadsheets are expressed in metric tons. The units of the raw data used as the basis for the activity indicator or the emission factors often required conversion to the units specified above. The following conversion factors were employed in many cases.

1 ton (metric)	=	1.1023 tons (short)
1 ton (long)	=	1.12 tons (short)
1 ton (short)	=	0.9072 tons (metric)
1 lb (metric)	=	1.1023 lb
1 bbl	=	42 gal

Emission factors were based on the most recent information available as of 1992. For many categories, this most recent emission factor was used to estimate emissions for all years. For some categories, the emission factor was the weighted average of emission factors for more specific subprocesses, equipment types, or other subcategories. Weighting factors used to calculate an average emission factor were often based on the relative activity of contributing subprocesses. In cases where the activities of the subprocesses changed from one year to the next, the emission factors also varied over time. Sulfur content or ash content of some fuels varied over time producing yearly variations in the SO_2, TSP, or PM-10 emission factors.

The PM-10 emission factors for some emission sources are not provided in the published documents referenced within this section. In these cases, the emission factors may be found in the supplemental list presented in Table 3.1-3. Therefore, the references given throughout this section are the possible sources of PM-10 emission factors, including published documents and Table 3.1-3.

Control efficiencies were calculated from information provided in the latest AIRS/AFS extraction utilizing the standard report number AFP650. This standard report contains emissions, annual throughput (when available), and number of facilities by Source Classification Codes (SCC). If a AIRS/AFS snapshot is not available for the current year, the current year's control efficiency was estimated by projecting the previous years' results. Also one should use a projection of previous years' results if the calculated control efficiency is nonsense. This could easily result if the operating rates (a confidential field in AIRS/AFS) of several SCCs are not extracted and the calculated control efficiency would be very low compare to previous year.

Calculation of the control efficiency involves three steps.

1. Calculate uncontrolled emissions for the SCC or SCCs that incorporate a source category. This is done by multiplying the operating rate by the latest emissions factor and converting to appropriate units.

2. Add all uncontrolled and then all controlled emissions separately.

3. Calculate a percentage control efficiency as follows:

$$\% \begin{array}{c} Control \\ efficiency \end{array} = \frac{\left(\begin{array}{cc} Uncontrolled & Actual \\ emissions & emissions \end{array} \right)}{\left(\begin{array}{c} Uncontrolled \\ emissions \end{array} \right)} \times 100 \qquad \text{(Eq. 3.1-2)}$$

The following information used in the next two equations, can be obtained from the AFP650 Report or AP-42.

SCC	1-01-005-04	1-01-005-01
Operating rate (1000 gallons)	419,478	72,889
PM-10 Emission Factor (lbs per 1000 gallons)	5.19	1.0
PM-10 Actual Emissions (tons)	723	11
The following information was calculated.		
PM-10 Uncontrolled Emissions (tons)	1,089	36

For SCC = 1-01-005-04

$$\begin{array}{c} Uncontrolled \\ emissions \end{array} = 419478 \left[\frac{1000}{gallons} \right] \times 5.19 \left[\frac{lbs}{\frac{1000}{gallons}} \right] \times \frac{1[ton]}{2000[lbs]}$$

For SCC = 1-01-005-01

$$\begin{array}{c} Uncontrolled \\ emissions \end{array} = 72889 \left[\frac{1000}{gallons} \right] \times 1.0 \left[\frac{lbs}{\frac{1000}{gallons}} \right] \times \frac{1[ton]}{2000[lbs]}$$

The control efficiency for this source category was calculated as follows:

$$\% \begin{array}{c} Control \\ efficiency \end{array} = \frac{\left((1089 + 36) - (723 + 11) \right)[tons]}{(1089 + 36)[tons]} \times 100 = 35\%$$

NOTE: Since the estimates are based on input data which may be updated or revised from time to time, the estimating procedure may change. For example, the emission factors published in AP-42 may be revised. If this occurs, it is necessary to revise all previous estimates where the original emission factor was used. Similarly, fuel consumption data may change from one year to the next as the statistics produced by various trade associations and government agencies are revised. Therefore, it is necessary to revise previous annual estimates when revised data are available. During the estimation procedure, it will become known which previous estimates require updating. In addition, all information for the last calendar year may not be available. Therefore, the best available information is used with the intent to amend the estimates as necessary in the following year.

3.1.2   Organization of Procedures

The 1940-1984 Methodology used to estimate emissions is described by Tier II category. For each category the procedure is divided into four sections: (1) technical approach, (2) activity indicator, (3) emission factor, and (4) control efficiency. The procedures for obtaining the activity indicators, emission factors or control efficiencies are arranged in a variety of different ways, depending on the specific requirements of the category (e.g., by pollutant, process, or fuel type).

References are provided at the end of the description of procedures for each Tier II category. Many of these references are published annually as part of a series. In some cases, several references are provided for the same information reflecting a change or discontinuation of one source and its replacement by another. The specific source used would depend on the specific year for which information was needed. All tables and supporting data immediately follow the description of the procedures for each Tier II category.

Table 3.1-1. Correspondence Between Tier II Categories and 1940-1984 Methodology Emission Source Categories

Tier I Category	Tier II Category	Tier I/Tier II Code	1940-1984 Methodology Emission Source Categories	1940-1984 Methodology Emission Source Subcategories
Fuel Combustion - Electric Utility	Coal	01-01	Bituminous Coal and Lignite	Electric Utility
			Anthracite Coal	Electric Utility
	Oil	01-02	Residual Oil	Electric Utility
			Distillate Oil	Electric Utility
	Gas	01-03	Natural Gas	Electric Utility
Fuel Combustion - Industrial	Coal	02-01	Bituminous Coal and Lignite	Industrial
			Anthracite Coal	Industrial
	Oil	02-02	Residual Oil	Industrial
			Distillate Oil	Industrial
			Industrial Processes - CO Emissions	Process Heaters (oil)
			Industrial Processes - NO$_x$ Emissions	Petroleum Refineries (process heaters - oil)
			Industrial Processes - PM-10 Emissions	Miscellaneous Process Sources (process heaters - oil)
			Industrial Processes - SO$_2$ Emissions	Other Industrial Processes (petroleum refineries - process heaters (oil))
			Industrial Processes - VOC Emissions	Petroleum Refinery Process Operation (process heaters - oil)

Table 3.1-1 (continued)

Tier I Category	Tier II Category	Tier I/Tier II Code	1940-1984 Methodology Emission Source Categories	1940-1984 Methodology Emission Source Subcategories
Fuel Combustion - Electric Utility	Coal	01-01	Bituminous Coal and Lignite	Electric Utility
			Anthracite Coal	Electric Utility
Fuel Combustion - Industrial, con't.	Gas	02-03	Natural Gas	Industrial (boilers and gas pipelines and plants)
			Miscellaneous Fuels	Industrial (coke-oven gas)
			Industrial Processes - CO Emissions	Process Heaters (gas)
			Industrial Processes - NO_x Emissions	Petroleum Refineries (process heaters - gas)
			Industrial Processes - PM-10 Emissions	Miscellaneous Process Sources (process heaters - gas)
			Industrial Processes - SO_2 Emissions	Other Industrial Processes (petroleum refineries - process heaters (gas))
			Industrial Processes - VOC Emissions	Petroleum Refinery Process Operation (process heaters - gas)
	Other	03-04	Miscellaneous Fuels	Industrial (coke, bagasse, kerosene, LPG, and wood)

Table 3.1-1 (continued)

Tier I Category	Tier II Category	Tier I/Tier II Code	1940-1984 Methodology Emission Source Categories	1940-1984 Methodology Emission Source Subcategories
Fuel Combustion - Electric Utility	Coal	01-01	Bituminous Coal and Lignite	Electric Utility
			Anthracite Coal	Electric Utility
Fuel Combustion - Other	Commercial and Institutional Coal	03-01	Bituminous Coal and Lignite	Commercial and Institutional
			Anthracite Coal	Commercial and Institutional
	Commercial and Institutional Oil	03-02	Residual Oil	Commercial and Institutional
			Distillate Oil	Commercial and Institutional
	Commercial and Institutional Gas	03-03	Natural Gas	Commercial and Institutional
	Residential Wood	03-05	Miscellaneous Fuels	Residential (wood)
	Residential Other	03-06	Bituminous Coal and Lignite	Residential
			Anthracite Coal	Residential
			Residual Oil	Residential
			Distillate Oil	Residential
			Natural Gas	Residential
			Miscellaneous Fuels	Residential (kerosene and LPG)

Table 3.1-1 (continued)

Tier I Category	Tier II Category	Tier I/Tier II Code	1940-1984 Methodology Emission Source Categories	1940-1984 Methodology Emission Source Subcategories
Fuel Combustion - Electric Utility	Coal	01-01	Bituminous Coal and Lignite Anthracite Coal	Electric Utility Electric Utility
Chemical and Allied Product Manufacture	Organic Chemical Manufacturing	04-01	Industrial Processes - CO Emissions	Charcoal Petrochemicals
			Industrial Processes - NO_x Emissions	Petrochemicals Charcoal
			Industrial Processes - PM-10 Emissions	Chemical Industry (petrochemicals)
			Industrial Processes - VOC Emissions	Manufacture of Petrochemicals (all subcategories, excluding storage and handling and waste disposal) Miscellaneous Industrial Processes [miscellaneous chemical products (charcoal)]
	Inorganic Chemical Manufacturing	04-02	Industrial Processes - CO Emissions	Ammonia Titanium Dioxide - chloride process
			Industrial Processes - NO_x Emissions	Ammonia Nitric Acid
			Industrial Processes - PM-10 Emissions	Chemical Industry (sulfuric acid and calcium carbide)
			Industrial Processes - SO_2 Emissions	Other Industrial Processes (sulfuric acid)
			Industrial Processes - VOC Emissions	Miscellaneous Industrial Processes [miscellaneous chemical products (ammonia)]

Table 3.1-1 (continued)

Tier I Category	Tier II Category	Tier I/Tier II Code	1940-1984 Methodology Emission Source Categories	1940-1984 Methodology Emission Source Subcategories
Fuel Combustion - Electric Utility	Coal	01-01	Bituminous Coal and Lignite	Electric Utility
			Anthracite Coal	Electric Utility
Chemical and Allied Product Manufacture, cont.	Polymer and Resin Manufacturing	04-03	Industrial Processes - VOC Emissions	Miscellaneous Industrial Processes [plastics manufacture (all subcategories, excluding fabrication) and miscellaneous chemical products (synthetic fibers and synthetic rubber)]
	Agricultural Chemical Manufacturing	04-04	Industrial Processes - PM-10 Emissions	Chemical Industry [fertilizers (ammonium nitrate, diammonium phosphate, and urea)]
	Pain, Varnish, Lacquer, and Enamel Manufacturing	04-05	Industrial Processes - VOC Emissions	Miscellaneous Industrial Processes [miscellaneous chemical products (paint)]
	Pharmaceutical Manufacturing	04-06	Industrial Processes - VOC Emissions	Miscellaneous Industrial Processes [miscellaneous chemical products (pharmaceuticals)]
	Other Chemical Manufacturing	04-07	Industrial Processes - CO Emissions	Carbon Black Production (oil process, gas process, and channel process)
			Industrial Processes - PM-10 Emissions	Chemical Industry [carbon black production (oil process, gas process, and channel process), charcoal, and soap and detergent]
			Industrial Processes - SO$_2$ Emissions	Other Industrial Processes (carbon black)
			Industrial Processes - VOC Emissions	Miscellaneous Industrial Processes [miscellaneous chemical products (carbon black - oil process and gas process)]

Table 3.1-1 (continued)

Tier I Category	Tier II Category	Tier I/Tier II Code	1940-1984 Methodology Emission Source Categories	1940-1984 Methodology Emission Source Subcategories
Fuel Combustion - Electric Utility	Coal	01-01	Bituminous Coal and Lignite	Electric Utility
			Anthracite Coal	Electric Utility
Metals Processing	Nonferrous	05-01	Industrial Processes - CO Emissions	Primary Aluminum
			Industrial Processes - PM-10 Emissions	Primary Metals Industry (aluminum, copper, zinc, and lead) Secondary Metal Industry (aluminum, copper, and lead)
			Industrial Processes - SO$_2$ Emissions	Nonferrous Smelters Other Industrial Processes (primary aluminum and secondary lead)
	Ferrous	05-02	Industrial Processes - CO Emissions	Iron Foundries Steel Manufacturing
			Industrial Processes - NO$_x$ Emissions	Iron and Steel
			Industrial Processes - PM-10 Emissions	Iron and Steel Industry Primary Metals Industry (ferroalloys) Secondary Metals Industry (grey iron foundries and steel foundries)
			Industrial Processes - SO$_2$ Emissions	Other Industrial Processes (iron and steel)
			Industrial Processes - VOC Emissions	Miscellaneous Industrial Processes [other processes (by-product coke and sintering)]
	Not Elsewhere Classified	05-03	Industrial Processes - PM-10 Emissions	Mining Operations

Table 3.1-1 (continued)

Tier I Category	Tier II Category	Tier I/Tier II Code	1940-1984 Methodology Emission Source Categories	1940-1984 Methodology Emission Source Subcategories
Fuel Combustion - Electric Utility	Coal	01-01	Bituminous Coal and Lignite	Electric Utility
			Anthracite Coal	Electric Utility
Petroleum and Related Industries	Oil and Gas Production	06-01	Industrial Processes - SO_2 Emissions	Other Industrial Processes [sulfur recovery plants (natural gas fields)]
			Industrial Processes - VOC Emissions	Petroleum Marketing and Production (crude oil production and natural gas liquids)
	Petroleum Refineries and Related Industries	06-02	Industrial Processes - CO Emissions	Petroleum Refineries
			Industrial Processes - NO_x Emissions	Petroleum Refineries (FCC, TCC, and flares)
			Industrial Processes - PM-10 Emissions	Miscellaneous Process Sources (petroleum refining)
			Industrial Processes - SO_2 Emissions	Other Industrial Processes [sulfur recovery plants (refineries) and petroleum refineries (FCC, TCC,and flares)]
			Industrial Processes - VOC Emissions	Petroleum Refinery Process Operation (refinery operations, compressors, blow down systems, process drains, vacuum jets, cooling towers, and miscellaneous)
	Asphalt Manufacturing	06-03	Industrial Processes - PM-10 Emissions	Mineral Products Industry (asphalt batching and asphalt roofing)
			Industrial Processes - VOC Emissions	Petroleum Refinery Process Operation (asphalt blowing)

Table 3.1-1 (continued)

Tier I Category	Tier II Category	Tier I/Tier II Code	1940-1984 Methodology Emission Source Categories	1940-1984 Methodology Emission Source Subcategories
Fuel Combustion - Electric Utility	Coal	01-01	Bituminous Coal and Lignite	Electric Utility
			Anthracite Coal	Electric Utility
Other Industrial Processes	Agriculture, Food, and Kindred Products	07-01	Industrial Processes - PM-10 Emissions	Agricultural Industries
			Industrial Processes - VOC Emissions	Miscellaneous Industrial Processes [other processes (bakeries, fermentation, and vegetable oil)]
	Wood, Pulp and Paper, and Publishing Products	07-03	Industrial Processes - CO Emissions	Kraft Pulp and Paper
			Industrial Processes - NO_x Emissions	Kraft Pulp
			Industrial Processes - PM-10 Emissions	Miscellaneous Process Sources (pulp and paper, semi-chemical, plywood, and lumber)
			Industrial Processes - SO_2 Emissions	Other Industrial Processes (kraft pulp production and sulfite)
	Rubber and Miscellaneous Plastic Products	07-04	Industrial Processes - VOC Emissions	Miscellaneous Industrial Processes [other processes (tires)]

Table 3.1-1 (continued)

Tier I Category	Tier II Category	Tier I/Tier II Code	1940-1984 Methodology Emission Source Categories	1940-1984 Methodology Emission Source Subcategories
Fuel Combustion - Electric Utility	Coal	01-01	Bituminous Coal and Lignite	Electric Utility
			Anthracite Coal	Electric Utility
Other Industrial Processes, con't.	Mineral Products	07-05	Industrial Processes - CO Emissions	Asphalt Roofing Lime
			Industrial Processes - NO_x Emissions	Cement Manufacturing Glass Manufacturing Lime
			Industrial Processes - PM-10 Emissions	Mineral Products Industry (cement manufacturing, bricks, clay sintering, concrete batching, fiber glass, glass, gypsum manufacturing, and lime manufacturing) Mining Operations (coal mining, sand and gravel, stone and rock crushing, phosphate rock, clays, and potash) Chemical Industry [fertilizers (rock pulverization)]
			Industrial Processes - SO_2 Emissions	Other Industrial Processes (cement manufacturing, glass manufacturing, and lime processing)
			Industrial Processes - VOC Emissions	Miscellaneous Industrial Processes [other processes (glass manufacturing)]

Table 3.1-1 (continued)

Tier I Category	Tier II Category	Tier I/Tier II Code	1940-1984 Methodology Emission Source Categories	1940-1984 Methodology Emission Source Subcategories
Fuel Combustion - Electric Utility	Coal	01-01	Bituminous Coal and Lignite Anthracite Coal	Electric Utility Electric Utility
Solvent Utilization	Degreasing	08-01	Industrial Processes - VOC Emissions	Miscellaneous Industrial Processes [other processes (degreasing)]
	Graphic Arts	08-02	Industrial Processes - VOC Emissions	Miscellaneous Industrial Processes [other processes (graphic arts)]
	Dry Cleaning	08-03	Industrial Processes - VOC Emissions	Miscellaneous Industrial Processes [other processes (dry cleaning)]
	Surface Coating	08-04	Industrial Processes - VOC Emissions	Miscellaneous Industrial Processes [other processes (adhesives)] Surface Coating Operations Miscellaneous Organic Solvent Evaporation (architectural coating, auto refinishing, and other solvent use)
	Other Industrial	08-05	Industrial Processes - VOC Emissions	Miscellaneous Industrial Processes [plastics manufacture (fabrication) and other processes (waste solvent recovery, organic solvent, and solvent extraction)]
	Nonindustrial	08-06	Industrial Processes - VOC Emissions	Miscellaneous Industrial Processes [other processes (fabric scouring)] Miscellaneous Organic Solvent Evaporation (cutback asphalt paving, pesticides, and other solvent use)
Storage and Transport	Bulk Terminals and Plants	09-01	Industrial Processes - VOC Emissions	Petroleum Marketing and Production (bulk gasoline terminals and gasoline bulk plants)
	Petroleum and Petroleum Product Storage	09-02	Industrial Processes - VOC Emissions	Petroleum Marketing and Production (gasoline storage at refineries, crude oil storage, and other products)

Table 3.1-1 (continued)

Tier I Category	Tier II Category	Tier I/Tier II Code	1940-1984 Methodology Emission Source Categories	1940-1984 Methodology Emission Source Subcategories
Fuel Combustion - Electric Utility	Coal	01-01	Bituminous Coal and Lignite Anthracite Coal	Electric Utility Electric Utility
Storage and Transport, cont.	Petroleum and Petroleum Product Transport	09-03	Industrial Processes - VOC Emissions	Petroleum Marketing and Production (refinery product loading and crude oil loading)
	Service Stations: Stage I	09-04	Industrial Processes - VOC Emissions	Petroleum Marketing and Production [gasoline service stations (loading or stage 1)]
	Service Stations: Stage II	09-05	Industrial Processes - VOC Emissions	Petroleum Marketing and Production [gasoline service stations (unloading or stage 2)]
	Organic Chemical Storage	09-07	Industrial Processes - VOC Emissions	Miscellaneous Industrial Processes [other processes (waste solvent recovery)] Manufacture of Petrochemicals (storage and handling)
Waste Disposal and Recycling	Incineration	10-01	Solid Waste Disposal	Incineration
	Open Burning	10-02	Solid Waste Disposal	Open Burning
	Other	10-07	Industrial Processes - VOC Emissions	Manufacture of Petrochemicals (waste disposal)
On-road Vehicles	(All Categories) Light-Duty Gas Vehicles and Motorcycles, Light-Duty Gas Trucks, and Heavy-Duty Gas Vehicles	11	On-road Vehicles	Gasoline (leaded and unleaded)

Table 3.1-1 (continued)

Tier I Category	Tier II Category	Tier I/Tier II Code	1940-1984 Methodology Emission Source Categories	1940-1984 Methodology Emission Source Subcategories
Fuel Combustion - Electric Utility	Coal	01-01	Bituminous Coal and Lignite Anthracite Coal	Electric Utility Electric Utility
Non-road Engines and Vehicles	Nonroad Gasoline Engines	12-01	Other Non-road Engines Vessels	Gasoline Gasoline
	Nonroad Diesel	12-02	Other Non-road Engines	Diesel
	Aircraft	12-03	Aircraft	all subcategories
	Marine Vessels	12-04	Vessels	Residual Fuel Oil Diesel Oil Coal
	Railroads	12-05	Railroads	all subcategories
Miscellaneous	Other Combustion (forest fires)	14-02	Forest fires and Prescribed Burning Other Miscellaneous Sources	all subcategories all subcategories

Table 3.1-2. Example Spreadsheet - Distillate Oil Combustion and Emission Factors for Year 19xx

Source Category	Consumption 10^6 gal	TSP Factors MLB/10^3 gal	SO$_2$ Factors MLB/10^3 gal	NO$_x$ Factors MLB/10^3 gal	VOC Factors MLB/10^3 gal	CO Factors MLB/10^3 gal	Pb Factors MLB/10^6 gal	PM-10 Factors MLB/10^3 gal
Electric Utility	733.6	4.7	36.0	61.8	3.5	13.2	0.38	4.1
Industrial	3378.1	2.6	35.6	29.5	1.0	7.0	0.38	1.73
Commercial-Institutional	3555.2	1.8	39.9	18.1	0.3	4.5	0.38	0.98
Residential	6152.5	2.3	31.6	16.3	0.6	4.5	0.38	2.23
Total	13819.4							

PM-10 Control Efficiencies for Distillate Oil

Electric Utility	0.565
Industrial	0.096
Commercial-Institutional	0.123
Residential	0

Nationwide Emissions from Distillate Oil Combustion

Source Category	TSP Emissions 1000 MT	SO$_2$ Emissions 1000 MT	NO$_x$ Emissions 1000 MT	VOC Emissions 1000 MT	CO Emissions 1000 MT	Pb Emissions Megagrams	PM-10 Emissions 1000 MT
Electric Utility	1.7	8.7	2.8	0.0	4.8	0.1	0.7
Industrial	4.4	60.2	49.8	1.7	11.8	0.6	2.6
Commercial-Institutional	3.2	70.9	32.2	0.5	8.0	0.7	1.5
Residential	7.1	97.3	50.1	1.8	13.8	1.2	6.9
Total	16.4	237.0	135.0	4.1	38.5	2.6	11.7

NOTES:

$$\text{gal} = \text{gallon};\ \text{MLB} = \frac{\text{lb}}{\text{ton}} * \frac{\text{ton}}{1.1023\ \text{metric ton}};\ \text{and MT} = \text{metric ton}$$

Table 3.1-3. Supplemental PM-10 Emission Factors

1940 - 1984 Methodology Emission Sources	TSP lb/unit	PM-10 lb/unit	PM-10 Mlb/unit	Units
External Combustion, Boilers				
Industrial				
coke, petroleum	1.5	1.2	1.09	tons burned
Residential				
Distillate oil	2.5	2.46	2.23	10^3 gallons
Kerosene	2.5	2.46	2.23	10^3 gallons
Wood				
Stoves	40.2	40.2	36.5	tons burned
Fireplaces	28.0	28.0	25.4	tons burned
Chemical Industry				
Plastics Production				
Polyethylene	1.0	0.66	.599	tons product
Primary Metals				
Copper				
Fugitives	26.5	17.5	14.42	tons of ore concentrate
Ferroalloys				
Other Ferroalloys	300.0	234.0	212.29	tons produced
Ferroalloy Handling	28.0	18.5	16.78	tons processed
Lead				
Fugitives	25.8	22.0	19.95	tons of ore concentrate
Zinc				
Fugitives	7.5	6.4	5.81	tons of ore concentrate
Mining Operations				
Copper Ore				
Crushing	8.6	3.9	3.54	tons of ore processed
Open pit overburden removal	0.0008	0.0003	0.00027	tons of ore processed
Drill/blasting	0.001	0.0008	0.00073	tons of ore processed
Loading	0.05	0.022	0.019958	tons of ore processed
Truck dumping	0.04	0.032	0.0290	tons of ore processed
Transfer/conveying	0.15	0.08	0.0726	tons of ore processed
Ore crushing	6.4	2.9	2.631	tons of ore processed
Storage	2.0	0.7	0.635	tons of ore processed
Iron Ore Mining	0.44	0.18	0.16	tons of ore processed
Lead Ore Crushing	6.0	5.1	4.63	tons of ore processed
Zinc Ore Crushing	6.0	2.3	2.09	tons of ore processed
Coal				
Surface Mining	0.5	0.2	1.81	tons of coal mined
Coal Handling	0.5	0.17	0.15	tons of coal shipped
Pneumatic Dryer	3.0	1.5	1.36	tons of coal dried
Sand and Gravel	0.1	0.029	.026	tons of product
Secondary Metals				
Aluminum				
Fugitives	3.7	3.4	3.08	tons of metal produced
Copper				
Fugitives	10.7	6.4	5.81	tons of charge
Grey Iron				
Fugitives	8.6	5.2	4.72	tons of metal charged
Steel Foundry				
Fugitives	13.0	7.8	7.08	tons of metal charged
Lead				
Fugitives	14.3	12.0	10.89	tons of metal charged

Table 3.1-3 (continued)

1940 - 1984 Methodology Emission Sources	TSP lb/unit	PM-10 lb/unit	PM-10 Mlb/unit	Units
Mineral Products				
Asphalt concrete				
Fugitives	0.3	0.15	0.14	tons of concrete produced
Brick Manufacture				
Material Handling	4.5	1.4	1.27	tons of raw material
Cement Manufacture				
Fugitives	18.0	10.4	9.44	tons of cement produced
Lime Manufacture				
Fugitives	4.7	1.75	1.59	tons of lime produced
Miscellaneous Process Sources				
Pulp and Paper				
Sulfite	14.0	12.6	11.4	ton air dry unbleached pulp
Semichemical, recovery furnace	24.0	22.3	20.2	ton air dry unbleached pulp
Wood Products				
Plywood	2.5	1.3	1.2	tons of plywood produced
Lumber	3.6	1.4	1.0	tons of lumber produced
Solid Waste Disposal				
Incinerators				
Residential Single Chamber				
w/o Primary Burner	35.0	13.0	11.8	tons of waste
w/ Primary Burner	7.0	4.7	4.3	tons of waste
Forest Fires and Prescribed Burning				
Forest Wild Fires	17.0	13.3	12.1	tons of vegetation burned
Prescribed Burning	20.0	15.6	14.2	tons of vegetation burned
Other Miscellaneous Sources				
Agricultural Burning	14.1	13.5	12.3	tons of vegetation burned
Structural Fires	16.0	6.0	5.4	tons of vegetation burned
Coal Refuse Fires	17.0	17.0	15.4	tons of vegetation burned
Non-road Vehicles				
Aircraft				
Commercial Aviation	1.0	1.0	0.9072	LTO
Air Taxi	.5	0.45	0.408	LTO
General Aviation	.2	0.18	0.163	LTO
Military	16.2	16.2	14.70	LTO
Railroads				
Diesel	25.0	25.0	22.68	10^3 Gallons
Residual	25.0	23.0	20.87	10^3 Gallons
Coal	60.0	31.0	28.12	Tons burned
Vessels				
Residual	19.3	17.8	16.15	10^3 Gallons
Diesel	24.0	24.0	21.77	10^3 Gallons
Gasoline	0.0	---		---

3.2 FUEL COMBUSTION ELECTRIC UTILITY - COAL: 01-01

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source categories.

Tier I Category	Tier II Category	Tier II Subcategory
(01) FUEL COMBUSTION - ELECTRIC UTILITY	(01) Coal	Bituminous, Subbituminous, and Lignite Coal Anthracite Coal

3.2.1 Technical Approach

The CO, NO_x, PM-10, TSP, SO_2, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, the activity indicator for bituminous coal was expressed in million short tons and the emission factors were expressed in metric pounds/short ton. The activity indicator for anthracite coal was expressed in thousand short tons and the emission factors were expressed in metric pounds/short ton. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to Equation 3.2-1.

$$PM\text{-}10 \ Emissions_{year} \ = \ PM\text{-}10 \ Emissions_{1975} \ \times \ \frac{TSP \ Emissions_{year}}{TSP \ Emissions_{1975}} \qquad \text{(Eq. 3.2-1)}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

The NO_x emissions produced by the combustion of bituminous coal by electric utilities were calculated with an applied 80 percent EPA-specified rule effectiveness for post-1977 years. Equation 3.2-2 summarizes this calculation.

$$Emissions_{NO_x , \ bit. \ coal} \ = \ AI_{bit. \ coal} \ \times \ EF_{NO_x , \ bit. \ coal} \ \times \ \left[1 \ - \ \left[RE \ \times \ \frac{CE_{NO_x , \ bit. \ coal}}{100} \right] \right] \quad \text{(Eq. 3.2-2)}$$

where: AI = activity indicator
        EF = emission factor
        RE = rule effectiveness of 0.80
        CE = control efficiency (expressed as a percentage)

3.2.2   Activity Indicator

The activity indicator for the combustion of anthracite coal by electric utilities was the anthracite coal receipts at electric utilities obtained from Reference 1a.

The activity indicator for bituminous, subbituminous, and lignite coal combustion was calculated as the difference between the total national consumption of coal by electric utilities and the anthracite coal consumption at electric utilities as determined above. The total national consumption of coal was obtained from Reference 2 or Reference 3.

3.2.3   Emission Factor

For the combustion of anthracite coal (SCC 1-01-001-xx), the emission factors for all pollutants except PM-10 were obtained from Reference 4a. The PM-10 emission factor was obtained from Reference 5. Emission factors for PM-10 and TSP were multiplied by an ash content value of 11 percent. The SO_2 emission factor was multiplied by the national average sulfur content value obtained from Reference 1.

For the combustion of bituminous, subbituminous, and lignitecoal (SCC 1-01-002-xx), the emission factors were the weighted averages of the emission factors for different firing configurations. The CO, NO_x, TSP, and VOC emission factors for each firing configuration were obtained from References 4b and 4c. The PM-10 emissions factors were obtained from Reference 5. The CO and VOC emission factors were weighted by the 1980 quantity of bituminous coal and lignite burned by industry in each firing configuration as reported in Reference 3. For the years 1977 through 1984, the NO_x, PM-10, and TSP emission factors were weighted by the national capacity of each boiler types determined annually. Boiler capacity data was based on 1976 data obtained from Reference 6. To update the capacity data after 1976, additional capacities of all coal-fired plants that came on line during each year between 1976 and the year under study were obtained from Reference 7. All new boilers added since 1977 were assumed to be pulverized dry bottom tangentially-fired boilers and were subject to New Source Performance Standards. These weighting factors were used to determine the bituminous coal and the lignite emission factors for NO_x, PM-10, and TSP. The weighted averages of these two emission factors for each of the three pollutants were calculated using the total fuel receipts obtained from Reference 1a as weighting factors. Ash contents of 13 percent for bituminous coal and 11 percent for lignite were applied to the PM-10 and TSP emission factors.

No specific information concerning the procedures for determining the NO_x and TSP emission factors for the years prior to 1977 or the PM-10 emission factor for 1975 through 1977 is currently available. Emission factors were not used in the estimations of PM-10 emissions prior to 1975.

The uncontrolled SO_2 emission factor was the weighted average of the bituminous, subbituminous and lignite SO_2 emission factors obtained from Reference 4. Weighting factors were the quantity of fuel receipts at electric utilities for steam plants with a capacity greater than 50 MW as reported in Reference 1. Each emission factor was multiplied by the sulfur content value obtained from Reference 8. The calculation is summarized in Equation 3.2-3.

$$EF_{uncontrolled} = \frac{(Q_B \times EF_B \times S_B) + (Q_{SB} \times EF_{SB} \times S_{SB}) + (Q_L \times EF_L \times S_L)}{Q_B + Q_{SB} + Q_L}$$ (Eq. 3.2-3)

where:
EF = uncontrolled emission factor
Q = quantity of fuel receipts
S = sulfur content value
B = bituminous coal
SB = subbituminous coal
L = lignite coal

This uncontrolled emission factor was adjusted for emission controls using the control efficiency, resulting in a controlled emission factor. The procedure for determining the control efficiency is presented in the next section.

3.2.4   Control Efficiency

3.2.4.1   Anthracite Coal

The TSP control efficiency was obtained from Reference 9. When this source was unavailable, a control efficiency of 99 percent was used.

The PM-10 control efficiencies for the years 1975 through 1984 were based on the 1988 PM-10 control efficiency obtained from Reference 10. During these years, any changes in the TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were use to estimate PM-10 emissions.

No control efficiencies were applied to the activity data to estimate the CO, NO_x, SO_2, or VOC emissions from this source.

3.2.4.2   Bituminous, Subbituminous, and Lignite Coal

The TSP control efficiencies were derived from the uncontrolled and controlled emissions. Uncontrolled TSP emissions were calculated for all point sources with SCCs 101002xx and 101003xx by multiplying the operating rates as obtained from NEDS or AIRS (References 6 and 11) by the appropriate emission factors (see preceding section). These products were summed to obtain the total uncontrolled TSP emissions. The controlled TSP emissions for all point sources with SCCs 101002xx and 101003xx were obtained from Reference 6 or Reference 11 and summed to obtain the total

controlled TSP emissions. These values were used in Equation 3.2-4 to calculate the TSP control efficiencies.

$$CE \ = \ \left[\frac{(UE-AE)}{UE} \right]$$
(Eq. 3.2-4)

where: CE =   control efficiency
          UE =   uncontrolled emissions
          AE =   controlled emissions

The PM-10 control efficiencies for the years 1975 through 1984 were based on the 1988 PM-10 control efficiency obtained from Reference 10. During these years, any changes in the TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate the PM-10 emissions.

No control efficiencies were applied to the activity data to estimate the CO, NO_x, or VOC emissions from bituminous, subbituminous, and lignite coal combustion.

The SO_2 control efficiency was based on plant level information on the amount of SO_2 removed by the control devices. The control efficiency was then applied to the uncontrolled emission factor to obtain the controlled SO_2 emission factor.

The following information was obtained from Reference 12: (1) plant and unit name and number, (2) percentage of SO_2 removed, and (3) commercial start-up date. The amount of SO_2 removed at each plant was calculated using this information along with the amount of coal consumed by the plant obtained from Reference 1b or Reference 13, the unit and plant capacity obtained from Reference 8, the percent sulfur content obtained from Reference 1, and the uncontrolled SO_2 emission factor for the combustion of bituminous coal at electric utilities (see preceding section). The amount of SO_2 removed at each plant was calculated according to Equation 3.2-5.

$$SO_{2,removed} \ = \ C \times \left[\frac{UC}{PC} \right] \times EF_{uncontrolled} \times RF \times SC \times OP$$
(Eq. 3.2-5)

where: C   =   coal consumed at plant
          UC =   unit capacity at plant
          PC =   total plant capacity
          EF = SO_2 emission factor
          RF =   fraction of SO_2 removed at plant
          SC =   sulfur content
          OP =   fraction of year plant in operation (assumed that the month after start-up date was first full month of operation)

The SO_2 removed at each unit was summed to obtain the national total SO_2 removed. The SO_2 control efficiency was calculated according to Equation 3.2-6 and was then applied to the uncontrolled emission factor to obtain the controlled emission factor.

$$CE_{SO_2} = \frac{SO_{2,\,removed}}{EF_{uncontrolled} \times AI_{Bituminous\,Coal}} \qquad \text{(Eq. 3.2-6)}$$

where: CE   =   control efficiency
            EF   =   emission factor
            AI   =   activity indicator

3.2.5   References

1. *Cost and Quality of Fuels for Electric Utility Plants*. DOE/EIA-0191(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
   (a) Table entitled, "Receipts of Coal by Rank Census Division, and State, [YEAR]"
   (b) Appendix A

2. *Electric Power Annual*. DOE/EIA-0348(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.

3. *Quarterly Coal Report: January - March*. DOE/EIA-0121(xx/1Q). Energy Information Administration, U.S. Department of Energy, Washington, DC. Quarterly.

4. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency. Research Triangle Park, NC. September 1991.
   (a) Volume I, Table 1.2-1, Supplement B, September 1988.
   (b) Volume I, Table 1.1-1
   (c) Volume I, Table 1.7-1

5. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listing for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

6. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual

7. Energy Data System, FPC 67 form run to print boiler capacity sorted by boiler type. 1976.

8. *Inventory of Power Plants in the United States 19xx*. DOE/EIA-0095(xx). U.S. Department of Energy, Energy Information Administration. Washington, DC. Annual.

9. *Computer Retrieval, NE257 report, by Source Classification Code (SCC) from the National Emission Data System (NEDS)*. Unpublished computer report. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. February 9, 1980.

National Air Pollutant Emission Trends
Procedures Document for 1900-1996   3-25   1940-1984 Methodology
         Category: 01-01

10. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends," Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990..

11. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS).* Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

12. Flue Gas Desulfurization Information System, FGDIS.

13. U.S. Department of Energy. Electric Generating Plant List (GURF) Report. Washington, DC.

3.3 FUEL COMBUSTION ELECTRIC UTILITY - OIL: 01-02

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source categories.

Tier I Category	Tier II Category	Tier II Subcategory
(01) FUEL COMBUSTION - ELECTRIC UTILITY	(02) Oil	Residual Distillate

3.3.1   Technical Approach

The CO, NO_x, PM-10, TSP, SO_2, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in million gallons and emission factors were expressed in metric pounds/thousand gallons. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to Equation 3.3-1.

$$PM\text{-}10 \ Emissions_{year} \ = \ PM\text{-}10 \ Emissions_{1975} \ \times \ \frac{TSP \ Emissions_{year}}{TSP \ Emissions_{1975}} \qquad \text{(Eq. 3.3-1)}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.3.2   Activity Indicators

The activity indicators for the combustion of residual and distillate oil were the consumption of these fuel types by electric utilities. Distillate oil consumption was assumed to be equal to the "adjusted" distillate fuel oil sales to electric utilities obtained from Reference 1 or Reference 2. Residual fuel oil consumption was obtained from Reference 1 or, when this reference was unavailable, the residual oil consumption was calculated as the difference between the total oil consumption and the distillate oil consumption. The total annual oil consumption was obtained from Reference 3.

3.3.3   Emission Factors

The emission factors for residual oil were calculated from the emission factors for the following four SCCs: 1-01-004-01, 1-01004-04, 1-01-004-05, and 1-01-004-05. For each pollutant, except PM-10, these emission factors were obtained from Reference 4a. The PM-10 emission factors were obtained from Reference 5. The SO_2 emission factors for these four SCCs were each the sum of the emission factors for SO_2 and SO_3. Each SO_3 emission factor was converted to an emission factor by weight of SO_2 prior to the summing by using the ratio of the molecular weights of SO_2 and SO_3 (i.e., 64/80). The SO_2, TSP, and PM-10 emission factors for these four SCCs were multiplied by the fuel sulfur content from Reference 6.

For each pollutant, the overall emission factor for the combustion of residual oil was the arithmetic average of the emission factors for the four SCCs, with the exception for the NO_x emission factor. The NO_x emission factors for the four SCCs were weighted by the residual oil capacity of each boiler type. Any additional capacity added since 1981 was assumed to be subject to the New Source Performance Standards. An emission factor of 45 lb/thousand gallons was assumed for these boilers and was weighted by the additional capacity. The yearly boiler capacities were obtained from Reference 7.

The emission factors for the combustion of distillate oil were calculated from the emission factors for the SCCs listed in Table 3.3-1. The emission factors for all pollutants except PM-10 were obtained from References 4a, 4b, and 4c. The PM-10 emission factors were obtained from Reference 5. Weighted averages of the boiler emission factors for each pollutant, except SO_2, were calculated using the weighting factors given in Table 3.3-1. Weighted average nonboiler emission factors for each pollutant, except SO_2, were calculated in the same manner.

The SO_2 emission factors for the four SCCs were multiplied by the fuel sulfur content for #2 and #4 heating oils obtained yearly from Reference 8. The #2 heating oil sulfur content was applied to the emission factors for the SCCs 1-01-005-01 and 2-01-001-01. The #4 heating oil sulfur content was applied to the SCC 1-01-005-04. No sulfur content was applied to the emission factor for reciprocating engines. Emission factors for the two boiler SCCs were weighted according to the distribution of #2 and #4 heating oils to electric utilities as reported in Reference 6. Emission factors for the nonboiler SCCs were weighted in the same manner as described for the other pollutants.

The overall emission factors for the combustion of distillate oil were the weighted average of the boiler and nonboiler emission factors for each pollutant. Weighting factors were dependent on the year for which the emission factors were being determined. For the years 1970 through 1980, the boiler emission factors were weighted 40 percent and the nonboiler emission factors were weighted 60 percent. After 1980, weighting factors were 50 percent for both boiler and nonboiler emission factors. The weighting factors used prior to 1970 are currently unavailable.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier II category.

3.3.4 Control Efficiency

The PM-10 control efficiencies for the combustion of residual and distillate oil for the years 1975 through 1984 were equal to the 1988 PM-10 control efficiencies obtained from Reference 9. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

No control efficiencies were applied to the activity data to estimate CO, NO_x, SO_2, TSP, or VOC emissions from the combustion of residual and distillate oil.

3.3.5 References

1. *Fuel Oil and Kerosene Sales 19xx*. DOE/EIA-0535(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.

2. *Petroleum Marketing Annual*. DOE/EIA-0389(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.

3. *Electric Power Annual*. DOE/EIA-0348(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.

4. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
   (a) Volume I, Table 1.3-1
   (b) Volume I, Table 3.1-2
   (c) Volume I, Table 3.3-1

5. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listings for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

6. *Cost and Quality of Fuels for Electric Utility Plants*. DOE/EIA-0191(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.

7. *Inventory of Power Plants in the United States 19xx*. DOE/EIA-0095(xx). U.S. Department of Energy, Energy Information Administration. Washington, DC. Annual.

8. *Heating Oils*. U.S. Department of Energy. Obtainable from the National Institute for Petroleum and Energy Research, ITT Research Institute, P.O. Box 2128. Bartlesville, OK. Annual.

9. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends," Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.

**Table 3.3-1. Emission Factor SCCs for Distillate
Oil Combustion by Electric Utility**

SCC	Description	Weighting Factors
1-01-005-01	Boiler - #2 oil	0.9
1-01-005-04	Boiler - #4 oil	0.1
2-01-001-01	Nonboiler - gas turbine	0.9
2-01-001-02	Nonboiler - reciprocating	0.1

3.4 FUEL COMBUSTION ELECTRIC UTILITY - GAS: 01-03

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source category.

Tier I Category	Tier II Category	Tier II Subcategory
(01) FUEL COMBUSTION - ELECTRIC UTILITY	(03) Gas	Natural Gas

3.4.1   Technical Approach

The CO, NO_x, PM-10, TSP, SO_2, and VOC emissions included in this Tier category were the sum of the emissions from the source category listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, the activity indicator was expressed in billion cubic feet and the emission factors were expressed in metric pounds/million cubic feet. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to Equation 3.4-1.

$$PM\text{-}10\ Emissions_{year}\ =\ PM\text{-}10\ Emissions_{1975}\ \times\ \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}} \qquad \text{(Eq. 3.4-1)}$$

This calculation was used in place of estimating PM-10 emissions based on activity indicators, emission factors, and control efficiencies.

3.4.2   Activity Indicator

The total annual natural gas consumption obtained from Reference 1 was the activity indicator for this category.

3.4.3   Emission Factor

The emission factors for all pollutants, except NO_x, were based on the emission factors for the five boiler and nonboiler types listed by SCC in Table 3.4-1. These emission factors for all pollutants except PM-10 were obtained from Reference 2a, 2b, and 2c. The PM-10 emission factors were obtained from Reference 3. Weighted average of the boiler emission factors were calculated using weighting factors obtained from Reference 4 or Reference 5. Weighted averages of the nonboiler emission factors were calculated using the weighting factors presented in Table 3.4-1. The overall weighted emission factors were calculated by weighting the boiler emission factors 94 percent and the nonboiler emission factors 6 percent.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the source included in this Tier II category.

The NO_x emission factors were based on the emission factors for the two nonboiler types listed in Table 3.4-1 and the following three boiler types listed in Table 3.4-2. The nonboiler emission factors were obtained from Reference 2b and 2c and were weighted in the same manner as for the other pollutants. The emission factors for the three boiler types are presented in Table 3.4-2. These emission factors were weighted by the boiler capacity data which was based on 1976 data obtained from Reference 6. In order to update the capacity data to a year after 1976, the additional capacities of plants that came on line each year between 1976 and the year under study were obtained from Reference 7. The procedure for determining the boiler capacities for the years prior to 1976 is currently unavailable. All new boilers added since 1983 were assumed to be subject to New Source Performance Standards and, therefore the new boiler capacity was added to this category. The resulting boiler capacities were used as weighting factors in the calculation of average NO_x emission factors for boilers. The overall weighted emission factors were calculated in the same manner as for the other pollutants.

3.4.4   Control Efficiency

The PM-10 control efficiencies for the combustion of natural gas for the years 1975 through 1984 were equal to the 1988 PM-10 control efficiency obtained from Reference 8. For the years 1940 through 1974, no control efficiencies were used to estimate the PM-10 emissions.

No control efficiencies were applied to the activity data to estimate the CO, NO_x, SO_2, TSP, or VOC emissions from the combustion of natural gas.

3.4.5   References

1. *Natural Gas Annual*. DOE/EIA-0131(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.

2. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
    (a) Volume I, Table 1.4-1, Supplement A, October 1986.
    (b) Volume I, Table 3.1-2, September 1985.
    (c) Volume I, Table 3.2-1, September 1985.

3. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listings for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

4. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

5. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

6. *Inventory of Power Plants in the United States 19xx*. DOE/EIA-0095(xx). U.S. Department of Energy, Energy Information Administration. Washington, DC. Annual.

7. Energy Data System, FPC 67 form run to print boiler capacity sorted by boiler type. 1976.

8. Barnard, William R. and Patricia M. Carlson. "PM-10 emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.

Table 3.4-1. Emission Factor SCCs for the Combustion of Natural Gas by Electric Utility

SCC	Description	Weighting Factors
1-01-006-01	Utility/Large Industrial Boiler	
1-01-006-02	Small Industrial Boiler	
1-01-006-04	Tangentially-Fired Boiler	
2-01-002-01	Nonboiler - gas turbine	0.9
2-01-002-02	Nonboiler - reciprocating engine	0.1

Table 3.4-2. NO_x Emission Factors by Boiler Types for the Combustion of Natural Gas by Electric Utility

Boiler Type	Emission Factor (lb/10^6 cu. ft.)
Normal	550
Tangential	275
New Source Performance Standard	200

3.5 FUEL COMBUSTION INDUSTRIAL - COAL: 02-01

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source categories.

Tier I Category	Tier II Category	Tier II Subcategory
(02) FUEL COMBUSTION - INDUSTRIAL	(01) Coal	Anthracite Bituminous, Subbituminous, and Lignite Coal

3.5.1   Technical Approach

The CO, NO_x, PM-10, TSP, SO_2, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order the utilize these values in the *Trends* spreadsheets, the activity indicator for bituminous, subbituminous, and lignite coal was expressed in million short tons and the emission factors were expressed in metric pounds/short ton. The activity indicator for anthracite coal was expressed in thousand short tons and the emission factors were expressed in metric pounds/short ton. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to Equation 3.5-1.

$$PM\text{-}10\ Emissions_{year}\ =\ PM\text{-}10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}} \qquad \text{(Eq. 3.5-1)}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.5.2   Activity Indicator

The activity indicator for the combustion of anthracite coal was the distribution of anthracite coal from Pennsylvania (i.e. District 24) obtained from Reference 1a under the category "Other Industrial".

The activity indicator for bituminous, subbituminous, and lignite coal was based on total national coal consumption obtained from Reference 2 under the category "Other Industrial." This value included the coal consumption from coke plants which were not appropriate for this activity indicator. Therefore, the coal consumption of cement plants and lime plants were subtracted from the total coal consumption. Coal consumption by cement plants was obtained from Reference 3. Coal consumption by lime plants was estimated by multiplying the lime production value obtained from Reference 4 by the conversion factor: 0.1 tons coal/ton lime produced.

3.5.3   Emission Factors

The emission factors for the combustion of anthracite coal were the weighted averages of the emission factors for three different firing configurations. For all pollutants except PM-10, the emission factors for each firing configuration were obtained from Reference 5a; the PM-10 emission factors were obtained from Reference 6. These emission factors were weighted by the 1980 quantity of anthracite coal burned by industry in each firing configuration as reported in Reference 7. An ash content of 11 percent was applied to selected PM-10 and TSP emission factors. The SO_2 emission factors were multiplied by a sulfur content value of 0.7 percent.

The emission factors for the combustion of bituminous, subbituminous, and lignite coal were the weighted average of the emission factors for the different firing configurations obtained from Reference 5b and 5c, respectively. These emission factors were weighted by the 1980 quantity of bituminous, subbituminous, and lignite coal burned by industry in each firing configuration as reported in Reference 7. The ash content was assumed to be 13 percent for bituminous and subbituminous coal, and 11 percent for lignite coal.

The SO_2 emission factor was multiplied by the average sulfur content for all coal shipped to industrial plants. The average sulfur content of coal was determined from the sulfur content by coal producing districts obtained for the category "Other industrial uses and retail dealers" in Reference 8a. This reference provided the sulfur content values reported in 1977 and it was assumed that these values remained constant during the years 1940 through 1984. In order to obtain the average sulfur content for a specific year, the sulfur content by district was weighted by the distribution of coal by district of origin for the category "Other Industrial" obtained from Reference 1a or Reference 9.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the source included in this Tier II category.

3.5.4   Control Efficiency

The TSP control efficiency for the combustion of anthracite coal was derived from Reference 10 or Reference 11 using Equation 3.5-2. When these values were unavailable, a control efficiency of 0.95 was used.

$$CE = \left[\frac{(UE - AE)}{UE}\right]$$

(Eq. 3.5-2)

where: CE = control efficiency
UE = emissions before control
AE = emissions after control

The TSP control efficiency for the combustion of bituminous, subbituminous, and lignite coal was calculated based on the uncontrolled and controlled emissions. In order to calculate the uncontrolled TSP emissions, the operating rates for each type of boiler using bituminous, subbituminous, and lignite coal (i.e., SCCs within the group 1-02-002-xx) were obtained from Reference 10 or Reference 11. These rates were multiplied by the corresponding emission factors obtained from Reference 5 and an ash content of 13 percent. The emissions were summed over all boiler types and converted to tons to obtain the total uncontrolled TSP emissions. The actual emissions reported in Reference 10 or Reference 11 were summed over the same boiler types to obtain the total actual TSP emissions. The TSP control efficiency was calculated from these values according to the equation given above.

The PM-10 control efficiencies for anthracite, bituminous, subbituminous, and lignite coal combustion for the years 1975 through 1984 were based on the 1988 PM-10 control efficiency obtained from Reference 12. During these years, any changes in the TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were use to estimate PM-10 emissions from the combustion of these fuels.

No control efficiencies were applied to the activity data to estimate CO, NO_x, SO_2, or VOC emissions from the combustion of anthracite coal and of bituminous coal and lignite.

3.5.5   References:

1. *Coal Distribution January-December 19xx.* DOE/EIA-0125(xx/4Q). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
    (a) Table entitled, "Domestic Distribution of U.S. Coal by Origin, Destination, and Consumer: January-December 19xx".

2. *Quarterly Coal Report: January - March.* DOE/EIA-0121(xx/1Q). Energy Information Administration, U.S. Department of Energy, Washington, DC. Quarterly.

3. *Minerals Industry Surveys*, Cement. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Monthly.

4. *Chemical and Engineering News, Facts and Figures Issue*. American Chemical Society, Washington, DC. Annual.

5. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.

a. Volume I, Table 1.2-1, Supplement B, September 1988.
b. Volume I, Table 1.1-1
c. Volume I, Table 1.7-1

6. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listing for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

7. *Computer Retrieval, NE257 report, by Source Classification Code (SCC) from the National Emission Data System (NEDS)*. Unpublished computer report. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. February 9, 1980.

8. *Coal Production*. DOE/EIA-0118(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
   (a) Table entitled, "Shipments of Bituminous Coal and Lignite by District, Consumer, Use, Average Sulfur Content - 1977."

9. *Minerals Yearbook*, Coal. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.

10. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

11. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

12. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.

3.6 FUEL COMBUSTION INDUSTRIAL - OIL: 02-02

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source categories.

Tier I Category	Tier II Category	Tier II Subcategory
(02) FUEL COMBUSTION - INDUSTRIAL	(02) Oil	Residual Distillate Process Heaters

3.6.1   Technical Approach

The CO, NO_x, PM-10, TSP, SO_2, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators for residual and distillate oil were expressed in million gallons and emission factors were expressed in metric pounds/thousand gallons. For CO, NO_x, PM-10, TSP, and SO_2 emissions, activity indicators for oil-fired process heaters were expressed in thousand short tons and emission factors were expressed in metric pounds/short ton. For VOC emissions, the activity indicator for process heaters was expressed in million barrels and the emission factors was expressed in metric pounds/thousand barrels. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to Equation 3.6-1.

$$PM\text{-}10\ Emissions_{year}\ =\ PM\text{-}10\ Emissions_{1975}\ \times\ \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}} \qquad \text{(Eq. 3.6-1)}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.6.2   Activity Indicator

The activity indicator for residual oil combustion was based on the adjusted quantity of residual oil sales for industrial and oil company use obtained from Reference 1 or 2. The total of three statistics were

---

subtracted from this value to obtain the activity indicator. The first statistic was two-thirds of the quantity of oil consumed by cement plants reported in Reference 3 converted to gallons. The second statistic was the quantity of residual oil consumed by petroleum refineries reported in Reference 4a, converted to gallons. The third statistic was the quantity of residual oil consumed by steel mills. This value was calculated by multiplying the quantity of raw steel production obtained from Reference 5, by 0.00738×10^6 gal/10^3 ton steel. The conversion factor between the gallons of oil and the tons of steel was updated in 1982 based on Reference 6.

The activity indicator for distillate oil combustion was based on the adjusted quantity of distillate oil sales to industrial and oil companies obtained from Reference 1 or 2. The total of two statistics were subtracted from this value to obtain the activity indicator for distillate oil. The first statistic was one-thirds of the quantity of oil consumed by cement plants, expressed in gallons, reported in Reference 3. The second statistic was the quantity of distillate oil consumed by petroleum refineries, expressed in gallons, reported in Reference 4a.

The activity indicator for oil-fired process heaters was the total quantity of oil consumed at petroleum refineries. This value was the sum of the distillate, residual and crude oil consumptions at petroleum refineries as reported in Reference 4a.

3.6.3   Emission Factor

The emission factors for each pollutant for the combustion of residual oil (SCC 1-02-004-01) were obtained from Reference 7 under the classification industrial boilers - residual oil for all pollutants except PM-10. The PM-10 emission factors were obtained from Reference 8. The SO_2, PM-10, and TSP emission factors were multiplied by the sulfur content obtained for No. 6 fuel oil from Reference 9.

The emission factors for each pollutant for the combustion of distillate oil were the weighted average of the emission factors for two SCCs (1-02-005-01 and 1-02-005-04). These emission factors were obtained from Reference 7 for all pollutants except PM-10. The PM-10 emission factors were obtained from Reference 8. Weighting factors were obtained from Reference 10.

The SO_2 emission factors were multiplied by a weighted average sulfur content. Sulfur content values for No. 1, No. 2, and No. 4 oils were obtained from Reference 9. These values were weighted by the corresponding distribution of fuel oil sales to the industrial sector as reported in Reference 1 or 2.

For oil-fired process heaters, the emission factors for all pollutants, except PM-10, were obtained from Reference 7 under the classification for industrial boiler - residual oil. The PM-10 emission factor was obtained from Reference 8.

 The TSP emission factor, as specified in Reference 7, was a function of sulfur content (10(S) + 3 lb/1,000 gal). The sulfur content was obtained for SCC 30600103 from Reference 10. The SO_2 and PM-10 emission factors were multiplied by the sulfur content. The VOC emission factor was converted to a reactive basis using the VOC species profile SDM 101004 from Reference 11.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier II category.

3.6.4   Control Efficiency

The PM-10 control efficiencies for all emission sources included in this Tier II category for the years 1975 through 1984 were equal to the 1988 PM-10 control efficiencies obtained from Reference 12. For the years 1940 through 1974, no control efficiencies were used to estimate the PM-10 emissions.

No control efficiencies were applied to the activity data to estimate CO, NO$_x$, SO$_2$, TSP, or VOC emissions from the source included in this Tier II category.

3.6.5   References

1. *Petroleum Marketing Monthly*. DOE/EIA-0380(xx/01). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.

2. *Fuel Oil and Kerosene Sales 19xx*. DOE/EIA-0535(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.

3. *Minerals Industry Surveys*, Cement. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Monthly.

4. *Petroleum Supply Annual*. DOE/EIA-0340(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
   a.   Table entitled, "Fuel Consumed at Refineries by PAD District."

5. *Survey of Current Business*. Bureau of Economic Analysis, U.S. Department of Commerce, Washington, DC.
   a.   Table containing information on Metals and Manufacturers

6. *Census of Manufactures (Fuels and Electric Energy Consumed)*. Bureau of the Census, U.S. Department of Commerce, Washington, DC. 1982.

7. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991. Volume I, Table 1.3-1

8. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listing for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

9. *Heating Oils*. U.S. Department of Energy. Obtainable from the National Institute for Petroleum and Energy Research, ITT Research Institute, P.O. Box 2128. Bartlesville, OK. Annual.

10. *Computer Retrieval, NE257 report, by Source Classification Code (SCC) from the National Emission Data System (NEDS)*. Unpublished computer report. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. February 9, 1980.

11. *Volatile Organic Compound (VOC) Species Data Manual.* EPA-450/4-80-015. U.S. Environmental Protection Agency, Research Triangle Park, NC. July 1980.

12. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.

3.7 FUEL COMBUSTION INDUSTRIAL - GAS: 02-03

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source categories.

Tier I Category	Tier II Category	Tier II Subcategory
(02) FUEL COMBUSTION - INDUSTRIAL	(03) Gas	Natural Gas - boilers and gas pipelines and plants Coke - oven gas Process Heaters

3.7.1   Technical Approach

The CO, NO_x, PM-10, TSP, SO_2, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators for natural and coke-oven gas were expressed in billion cubic feet and emission factors were expressed in metric pounds/million cubic feet. For CO, NO_x, PM-10, TSP, and SO_2 emissions, the activity indicator for gas-fired process heaters was expressed in thousand short tons and the emission factors were expressed in metric pounds/short ton. For VOC emissions, the activity indicator for gas-fired process heaters was expressed in million barrels and the emission factor was expressed in metric pounds/thousand barrels. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to Equation 3.7-1.

$$PM\text{-}10 \ Emissions_{year} \ = \ PM\text{-}10 \ Emissions_{1975} \ \times \ \frac{TSP \ Emissions_{year}}{TSP \ Emissions_{1975}} \qquad \text{(Eq. 3.7-1)}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.7.2   Activity Indicator

The activity indicator for the combustion of natural gas in industrial boilers was based on the total industrial consumption of natural gas obtained from Reference 1. From this value was subtracted the sum of the total natural gas consumption by cement plants, petroleum refineries, iron and steel industries, and glass manufacturers. Total natural gas consumption by cement plants obtained from Reference 2. Total natural gas consumption by petroleum refineries was obtained from Reference 3. The total natural gas consumption by iron and steel industries was calculated by multiplying the raw steel production obtained from Reference 4 by 4.25×10^6 cu. ft. natural gas/1000 tons steel. The conversion factor relating steel production to natural gas consumption was updated in 1982 based on data from Reference 5. Total natural gas consumption by glass manufacturers was determined from the total glass production. This total was calculated by summing the total production of flat glass from Reference 6 and the net packed weight of glass containers from Reference 7 and multiplying the resulting sum by 1.1 to account for miscellaneous glass products. The total glass production was multiplied by 10.8×10^6 cu. ft. natural gas/1000 tons glass produced to obtain the total natural gas consumption. The conversion factor relating glass production to natural gas consumption was updated in 1982 based on data from Reference 5.

The activity indicator for the combustion of natural gas by gas pipelines and plants was the total natural gas consumption for lease and plant fuel plus pipeline fuel obtained from Reference 1.

The activity indicator for coke-oven gas combustion represented the amount of coke-oven gas consumed outside of the iron and steel industry which was assumed to be 18.8 percent of the total coke-oven gas produced. The total coke-oven gas production, in cubic feet, as reported in Reference 8, was multiplied by 0.188 to obtain the activity indicator for this subcategory.

The activity indicator for gas-fired process heaters was the total of natural gas and still (process) gas consumed at petroleum refineries obtained from Reference 3.

3.7.3   Emission Factor

The emission factors for all pollutants except PM-10 for the combustion of natural gas in industrial boilers (SCC 1-02-006-02) were obtained from Reference 9a. The PM-10 emission factor was obtained from Reference 10.

The emission factors for the combustion of natural gas by gas pipeline and plants were the weighted averages of the emission factors for SCCs 2-02-002-01 and 2-02-002-02. Reference 9b was the source of the emission factors for all pollutants except PM-10; Reference 10 was the source for the PM-10 emission factors. The weighting factors were based on data from Reference 11.

The emission factors for all pollutants for the combustion of coke-oven gas were obtained from Reference 10. The SO_2 emission factor was multiplied by the constant sulfur content value of 1.605 percent.

The CO and NO_x emission factors for all types of gas-fired process heaters were obtained from Reference 9c. The PM-10 emission factor was obtained from Reference 10, the PM-10 and TSP emission factors were obtained from Reference 9a, and the VOC emission factor from Reference 9d. In

each case, the emission factors were listed as the uncontrolled emission factors for small industrial boilers. The VOC emission factor was converted to a reactive basis using the VOC species profile SDM 101007 from Reference 12.

The SO_2 emission factor was the weighted average of the emission factors for natural gas obtained from Reference 9c and for refinery gas (given as 356.25 lb/10^6 cu.ft.). The weighting factors were the natural gas and refinery gas consumption obtained from Reference 3.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier II category.

3.7.4 Control Efficiency

The PM-10 control efficiencies for all emission sources included in this Tier II category for the years 1975 through 1984 were equal to the 1988 PM-10 control efficiencies obtained from Reference 13. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

No control efficiencies were applied to the activity data to estimate CO, NO_x, SO_2, TSP, or VOC emissions from these sources.

3.7.5 References

1. *Natural Gas Annual*. DOE/EIA-0131(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.

2. *Minerals Industry Surveys*, Cement. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Monthly.

3. *Petroleum Supply Annual*. DOE/EIA-0340(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.

4. *Minerals Industry Surveys*, Iron Ore. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Monthly.

5. *Census of Manufactures (Fuels and Electric Energy Consumed)*. Bureau of the Census, U.S. Department of Commerce, Washington, DC. 1982.

6. *Current Industrial Reports*, Glass Containers. Bureau of the Census, U.S. Department of Commerce, Washington, DC. Annual.

7. *Current Industrial Reports*, Flat Glass. Bureau of the Census, U.S. Department of Commerce, Washington, DC. Annual.

8. *Quarterly Coal Report: January - March*. DOE/EIA-0121(xx/1Q). Energy Information Administration, U.S. Department of Energy, Washington, DC. Quarterly.

9. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42.* U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
   (a) Volume I, Table 1.4-1
   (b) Volume I, Table 3.2-1
   (c) Volume I, Table 1.4-2
   (d) Volume I, Table 1.4-3

10. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listing for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

11. *Computer Retrieval, NE257 report, by Source Classification Code (SCC) from the National Emission Data System (NEDS)*. Unpublished computer report. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. February 9, 1980.

12. U.S. Environmental Protection Agency. Volatile Organic Compound (VOC) Species Data Manual. EPA-450/4-80-015. Research Triangle Park, NC. July 1980.

13. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.

3.8 FUEL COMBUSTION INDUSTRIAL - OTHER: 02-04

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source category.

Tier I Category | Tier II Category | Tier II Subcategory

(02) FUEL COMBUSTION - INDUSTRIAL | (04) Other External Combustion | Coke, Bagasse, Kerosene, Liquid Petroleum Gas, and Wood

3.8.1   Technical Approach

The CO, NO_x, PM-10, TSP, SO_2, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators for coke, bagasse, and wood were expressed in thousand short tons and emission factors were expressed in metric pounds/short ton. For kerosene and LPG, activity indicators were expressed in million barrels and emission factors was expressed in metric pounds/thousand barrels. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to Equation 3.8-1.

$$PM\text{-}10 \ Emissions_{year} \ = \ PM\text{-}10 \ Emissions_{1975} \ \times \ \frac{TSP \ Emissions_{year}}{TSP \ Emissions_{1975}} \qquad \text{(Eq. 3.8-1)}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.8.2   Activity Indicator

The activity indicator for the combustion of coke was the consumption of coke outside the iron and steel industry. This quantity was calculated by summing the total coke production from coal and the total petroleum coke receipts. The total quantity of petroleum coke consumed or received by power plants was obtained from Reference 1 or Reference 2.

In order to obtain the total coke produced from coal, the following data were obtained from Reference 3: (1) total breeze production at coke plants and (2) coke sales to "other industrial plants." Because it was assumed that 24 percent of the total breeze production was sold for use as boiler fuel, the total breeze production at coke plants was multiplied 0.24 to obtain the total breeze consumed as fuel. If data for foundries and other industrial plants were combined, it was assumed that 49 percent of the total was for other industrial plants. Total coke production from coal was the sum of the total breeze production used for fuel and the total coke sales to other industrial plants. Alternatively, if data from Reference 3 were not available, it was assumed that 5.75 percent of total coke production obtained from Reference 3 represented the coke consumption outside the iron and steel industry.

The activity indicator for the combustion of bagasse was the consumption of bagasse obtained from Reference 4.

The activity indicator for the combustion of kerosene was the quantity of kerosene sales. This value was obtained by summing the sales figures reported for the industrial and the all other end use categories as reported in Reference 5 or Reference 6.

The activity indicator for the combustion of liquid petroleum gas was the LPG supplied for industrial use. This quantity was derived from the 1982 consumption figures ($5,397 \times 10^6$ gal) using the ratio between the quantity of products supplied in 1982 ($1,499 \times 10^3$ bbl/day) and in the year under study. The quantity of products supplied for a given year and for 1982 was obtained from Reference 7. The Equation 3.8-2 summarizes the calculation of the LPG supplied for industrial use:

$$LPG_{Industrial, \, i} \quad = \quad LPG_{Industrial, \, 1982} \quad \times \quad \frac{Products_{Supplied, \, i}}{Products_{Supplied, \, 1982}} \qquad \text{(Eq. 3.8-2)}$$

where: i   =   year under study

The activity indicator for the industrial combustion of wood was based on the consumption of wood for industrial combustion obtained from Reference 8. It was assume that 15 percent of the heating value was lost to moisture on a typical basis. Therefore, the reported consumption figure was multiplied by 0.85 to obtain the activity indicator.

3.8.3   Emission Factor

The emission factors for industrial coke combustion were the weighted averages of the emission factors for petroleum coke and coal coke. These emission factors for which the references are currently unavailable are presented in Table 3.8-1. Weighting factors were the total petroleum coke receipts and the total coke produced from coal as determined for the activity indicator for the coke category. A sulfur content value of 3.25 percent was used for the petroleum coke SO_2 emission factor.

The emission factors for bagasse combustion (SCC 1-02-001-01) were obtained from Reference 9a for all pollutants except PM-10. The PM-10 emission factor was obtained from Reference 10. The TSP control efficiency was applied directly to the TSP emission factor, resulting in the controlled emission factor. The TSP control efficiency was obtained from Reference 10.

The emission factors used for kerosene combustion (SCC 1-02-005-01) were those for the combustion of distillate oil in industrial boilers obtained from Reference 9b for all pollutants except PM-10. The PM-10 emission factor was obtained from Reference 10. The SO_2 emission factors was multiplied by a sulfur content value of 0.075 percent.

The emission factors for all pollutants for LPG combustion (SCC 1-02-010-01) were obtained from Reference 9c. The PM-10 emission factor was obtained from Reference 10. The SO_2 emission factor was multiplied by a sulfur content value of 0.0013 percent.

For industrial wood combustion the emission factors were the weighted averages of the emission factors for three SCCs (1-02-009-01, 1-02-009-02, and 1-02-009-03). These emission factors were obtained from Reference 9d for all pollutants except PM-10 which was obtained from Reference 10. For the years 1975 through 1984, the weighting factors were derived from throughput data obtained from Reference 11. Prior to 1975, the procedure for determining the weighting factors is currently unavailable.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier II category.

3.8.4   Control Efficiency

The PM-10 control efficiencies for all emission sources included in this Tier II category for the years 1975 through 1984 were equal to the 1988 PM-10 control efficiencies obtained from Reference 12. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

No control efficiencies were applied to the activity data to estimate CO, NO_x, SO_2, TSP, or VOC emissions from the source included in this Tier II category.

3.8.5   References

1. *Cost and Quality of Fuels for Electric Utility Plants*. DOE/EIA-0191(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.

2. *Electric Power Annual*. DOE/EIA-0348(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.

3. *Quarterly Coal Report: January - March*. DOE/EIA-0121(xx/1Q). Energy Information Administration, U.S. Department of Energy, Washington, DC. Quarterly.

4. *Standard Computer Retrievals, NE213 report (duel use summary), from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

5. *Fuel Oil and Kerosene Sales 19xx*. DOE/EIA-0535(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.

6. *Petroleum Marketing Monthly*. DOE/EIA-0380(xx/01). Energy Information Administration, U.S. Department of Energy, Washington, DC. January issue.

7. *Petroleum Supply Annual*. DOE/EIA-0340(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.

8. *Estimates of U.S. Biofuels Consumption*. SR/CNEAF/91-02. U.S. Department of Energy, Washington, DC. Annual.

9. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
    (a) Volume I, Table 1.8-1
    (b) Volume I, Table 1.3-1
    (c) Volume I, Table 1.5-1
    (d) Volume I, Table 1.6-1, Supplement A, October 1986

10. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listing for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

11. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

12. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.

Table 3.8-1. Emission Factors for Miscellaneous Fuels - Industrial (coke)

Coke Type	Emission Factors (lb/ton)					
	TSP	SO_2	NO_x	VOC	CO	PM-10
Petroleum Coke	1.5	38.8*	20.9	0.64	0.54	1.2
Coal Coke	4.6	30.3	14.0	0.64	0.54	3.6

* Multiply by sulfur content

3.9 FUEL COMBUSTION OTHER - COMMERCIAL/INSTITUTIONAL COAL: 03-01

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source categories.

Tier I Category	Tier II Category	Tier II Subcategory
(03) FUEL COMBUSTION - OTHER	(01) Commercial/Institutional Coal	Anthracite Coal Bituminous, Subbituminous, and Lignite Coal

3.9.1   Technical Approach

The CO, NO_x, PM-10, TSP, SO_2, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, the activity indicator for bituminous, subbituminous, and lignite coal was expressed in million short tons and the emission factors were expressed in metric pounds/short ton. The activity indicator for anthracite coal was expressed in thousand short tons and the emission factors were expressed in metric pounds/short ton. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to Equation 3.9-1.

$$PM\text{-}10\ Emissions_{year}\ =\ PM\text{-}10\ Emissions_{1975}\ \times\ \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}} \qquad \text{(Eq. 3.9-1)}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.9.2   Activity Indicator

The activity indicators for the combustion of these two fuels were the consumption of the specific coal type by commercial and institutional users. Determination of these activity indicators required the

activity indicators for both anthracite, bituminous, subbituminous, and lignite residential coal combustion. The latter activity indicators are described both here and in section 3.13.2.

The commercial/institutional consumption of anthracite coal was obtained by subtracting residential anthracite consumption from residential and commercial/institutional anthracite consumption. Residential and commercial/institutional consumption of anthracite coal was obtained from Reference 1a for District 24 only.

$$Anthracite\ Coal_{C/I}\ =\ Anthracite\ Coal_{R\ and\ C/I}\ -\ Anthracite\ Coal_R \qquad \text{(Eq. 3.9-2)}$$

where: C/I   =   commercial/institutional consumption
          R   =   residential consumption

Residential consumption of anthracite coal was determined by extrapolating the consumption of the previous year based on the change in the number of dwelling units in the Northeastern United States having coal as the main fuel for space heating. Data concerning the number of dwelling units was obtained from Reference 2. The calculation of the residential anthracite coal consumption is summarized in Equation 3.9-3.

$$Anthracite\ Coal_{R,\ i}\ =\ Anthracite\ Coal_{R,\ i-1}\ \times\ \frac{Dwelling\ Units_i}{Dwelling\ Units_{i-1}} \qquad \text{(Eq. 3.9-3)}$$

where: R   =   residential consumption
          i   =   year under study

Commercial/institutional consumption of bituminous, subbituminous, and lignite coal was obtained by subtracting residential bituminous, subbituminous, and lignite consumption from residential and commercial/institutional bituminous, subbituminous, and lignite consumption. Residential and commercial/institutional consumption of bituminous coal was calculated by subtracting the residential and commercial/institutional consumption of anthracite coal from residential and commercial/institutional consumption of all types of coal. These two consumption values were obtained from Reference 1a and excluded coal from District 24 which represents anthracite coal consumption. This calculation is summarized in Equation 3.9-4.

$$Bituminous\ Coal_{C/I}\ =\ (All\ Coal_{R\ and\ C/I}\ -\ Anthracite\ Coal_{R\ and\ C/I})\ -\ Bituminous\ Coal_R \qquad \text{(Eq. 3.9-4)}$$

where: C/I   =   commercial/institutional consumption
          R   =   residential consumption

Residential consumption of bituminous, subbituminous, and lignite coal was determined by estimating the quantity of all coal consumed by all dwelling units using coal as the main fuel and subtracting from this value the residential consumption of anthracite coal calculated above. The quantity of all coal consumed was calculated using the number of dwelling units using coal as the main fuel for space heating obtained from Reference 2 and a factor estimating the average annual consumption of coal per dwelling unit. This calculation is summarized in Equation 3.9-5.

$$Bituminous\ Coal_R = (Dwelling\ Units \times 6.73\ tons\ burned/dwelling/year) - Anthracite\ Coal_R \quad \text{(Eq. 3.9-5)}$$

3.9.3   Emission Factors

The emission factors for anthracite coal combustion were the weighted average of the emission factors for three different firing configurations. The emission factors for each firing configuration were obtained from Reference 3a for all pollutants except PM-10. The PM-10 emission factors were obtained from Reference 4. These CO, SO_2, and VOC emission factors were weighted by the 1980 quantity of anthracite coal burned by industry in each firing configuration as reported in Reference 5. The procedure for determining the weighting factors for the NO_x, PM-10 and TSP emission factors is currently unavailable, although it is known that the same factors were applied for the years 1940 through 1984. An ash content of 11 percent was applied to selected PM-10 and TSP emission factors. The SO_2 emission factors were multiplied by a sulfur content value of 0.7 percent.

The emission factors for the combustion of bituminous, subbituminous, and lignite coal were the weighted average of the emission factors for different firing configurations. For all pollutants except PM-10, these emission factors were obtained from Reference 3b and 3c. The PM-10 emission factors were obtained from Reference 4. These emission factors were weighted by the 1980 quantity of bituminous, subbituminous, and lignite coal burned by industry in each firing configuration as reported in Reference 5. The ash content was assumed to be 13 percent for bituminous coal and 11 percent for lignite.

The SO_2 emission factor was multiplied by the average sulfur content for all coal shipped to industrial plants. The average sulfur content of coal was determined from the sulfur content by coal producing districts obtained for the category "All other uses" in Reference 6a. This reference provided the sulfur content values reported in 1977 and it was assumed that these values remained constant during the years 1940 through 1984. In order to obtain the average sulfur content for a specific year, the sulfur content by district was weighted by the distribution of coal by district of origin for the category "Residential and Commercial" obtained from Reference 1a or Reference 7.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier II category.

3.9.4   Control Efficiency

The TSP control efficiency for the combustion of anthracite coal was obtained from Reference 8 or Reference 9. When this value was unavailable, a control efficiency of 33 percent was used.

For bituminous, subbituminous, and lignite coal, the TSP control efficiency was calculated based on the uncontrolled and controlled emissions. In order to calculate the uncontrolled TSP emissions, the operating rates for each type of boiler using bituminous and subbituminous coal and lignite (i.e. SCCs within the group 1-02-002-xx) were obtained from Reference 8 or Reference 9. These rates were multiplied by the corresponding emission factors obtained from Reference 3a and an ash content of 13 percent. The emissions were summed over all boiler types and converted to tons to obtain the total uncontrolled TSP emissions. The actual emissions reported in Reference 8 or Reference 9 were summed over the same boiler types to obtain the total actual TSP emissions. The TSP control efficiency was calculated from these values according to Equation 3.9-6.

$$CE = \left[\frac{(UE - AE)}{UE} \right]$$ (Eq. 3.9-6)

where: CE = control efficiency
          UE = uncontrolled emissions
          AE = controlled emissions

The PM-10 control efficiencies for anthracite coal and bituminous, subbituminous, and lignite coal combustion for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 10. During these years, any changes in the TSP control efficiencies from the 1985 TSP control efficiency values were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were use to estimate PM-10 emissions.

No control efficiencies were applied to the activity data to estimate CO, NO_x, SO_2, or VOC emissions from the combustion of anthracite coal and bituminous coal and lignite.

3.9.5   References

1. *Coal Distribution January-December 19xx*. DOE/EIA-0125(xx/4Q). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
    (a) table entitled "Domestic Distribution of U.S. Coal to the Residential and Commercial Sector by Origin."

2. *American Housing Survey, Current Housing Reports, Series H-150-83*. Bureau of the Census, U.S. Department of Commerce, Washington DC. Biennial.

3. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
    (a) Volume I, Table 1.2-1, Supplement B, September 1988.
    (b) Volume I, Table 1.1-2
    (c) Volume I, Table 1.7-1

4. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listings for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

5. *Computer Retrieval, NE257 report, by Source Classification Code (SCC) from the National Emission Data System (NEDS)*. Unpublished computer report. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. February 9, 1980.

6. *Coal Production*. DOE/EIA-0118(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
    (a) table entitled "Shipments of bituminous coal and lignite by district, consumer, use, and average sulfur content - 1977."

7. *Minerals Yearbook*, Coal. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.

8. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

9. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

10. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.

3.10   FUEL COMBUSTION OTHER - COMMERCIAL/INSTITUTIONAL OIL: 03-02

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source categories.

Tier I Category	Tier II Category	Tier II Subcategory
(03) FUEL COMBUSTION - OTHER	(02) Commercial/Institutional Oil	Residual Distillate

3.10.1   Technical Approach

The CO, NO$_x$, PM-10, TSP, SO$_2$, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in million gallons and emission factors were expressed in metric pounds/thousand gallons. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to Equation 3.10-1.

$$PM\text{-}10 \ Emissions_{year} \ = \ PM\text{-}10 \ Emissions_{1975} \ \times \ \frac{TSP \ Emissions_{year}}{TSP \ Emissions_{1975}} \qquad \text{(Eq. 3.10-1)}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.10.2   Activity Indicator

The activity indicator for residual oil combustion was the "adjusted" total quantity of residual oil sales for commercial and military use obtained from Reference 1 or Reference 2.

The activity indicator for distillate oil combustion was the "adjusted" total quantity of distillate oil sales for commercial and military use (<u>not</u> including military diesel fuel) obtained from Reference 1 or Reference 2.

3.10.3   Emission Factor

The emission factors for the combustion of residual oil were the weighted average of the emission factors for the combustion of Grade 6 and Grade 5 fuel oils (SCCs 1-03-004-01 and 1-03-004-04). For all pollutants except PM-10, these emission factors were obtained from Reference 3a. The PM-10 emission factors were obtained from Reference 4. The TSP, SO_2, and PM-10 emission factors for Grade 6 fuel oil and the SO_2 emission factor for Grade 5 fuel oil were multiplied by the average sulfur content. The weighted average emission factors were determined using the relative consumption of Grade 5 and Grade 6 fuel oils obtained from Reference 5 or Reference 6.

The average sulfur content for residual oil was calculated from sulfur content values obtained from Reference 7 for No. 5 light, No. 5 heavy and No. 6 oils. The sulfur content values for the two No. 5 oils were averaged. Weighting factors for the averaged No. 5 oils and the No. 6 oil were 0.13 and 0.87, respectively. Equation 3.10-2 summarizes this calculation.

$$S_{Residual\ Oil} = \left(\left[\frac{S_{No.\ 5\ light} + S_{No.\ 5\ heavy}}{2} \right] \times 0.13 \right) + (S_{No.\ 6} \times 0.87) \qquad \text{(Eq. 3.10-2)}$$

where: S   =   sulfur content

The emission factors for distillate oil combustion were the weighted averages of the emission factors for the SCCs 1-03-005-01 and 1-03-005-04. The emission factors were obtained from Reference 3b for all pollutants except PM-10. The PM-10 emission factors were obtained from Reference 4. The SO_2 emission factors for both SCCs were multiplied by a weighted average sulfur content. Sulfur content values for No. 1, No. 2, and No. 4 oils were obtained from Reference 7. These values were weighted by the corresponding commercial deliveries of each oil type reported in Reference 1 or Reference 2 to obtain the weighted average sulfur content. To determine the weighted average emission factors, throughput values for the corresponding SCCs obtained from Reference 5 or Reference 6 were used as weighting factors.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier II category.

3.10.4   Control Efficiency

The PM-10 control efficiencies for all emission sources included in this Tier II category for the years 1975 through 1984 were equal to the 1988 PM-10 control efficiencies obtained from Reference 7. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

No control efficiencies were applied to the activity data to estimate CO, NO_x, SO_2, TSP, or VOC emissions from the source included in this Tier II category.

3.10.5   References

1. *Petroleum Marketing Monthly*. DOE/EIA-0380(xx/01). Energy Information Administration, U.S. Department of Energy, Washington, DC. January issue.

2. *Fuel Oil and Kerosene Sales 19xx*. DOE/EIA-0535(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.

3. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
    a.   Volume I, Table 1.3-1
    b.   Volume I, Table 1.3-1

4. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listings for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

5. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

6. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

7. *Heating Oils*. U.S. Department of Energy. Obtainable from the National Institute for Petroleum and Energy Research, ITT Research Institute, P.O. Box 2128, Bartlesville, OK. Annual.

8. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.

3.11   FUEL COMBUSTION OTHER - COMMERCIAL/INSTITUTIONAL GAS: 03-03

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source category.

Tier I Category	Tier II Category	Tier II Subcategory
(03) FUEL COMBUSTION - OTHER	(03) Commercial/Institutional Gas	Natural Gas

3.11.1   Technical Approach

The CO, NO_x, PM-10, TSP, SO_2, and VOC emissions included in this Tier category were the emissions from the source category listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, the activity indicator was expressed in billion cubic feet and the emission factors were expressed in metric pounds/million cubic feet. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\text{-}10\ Emissions_{year}\ =\ PM\text{-}10\ Emissions_{1975}\ \times\ \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}} \qquad \text{(Eq. 3.11-1)}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.11.2   Activity Indicator

The activity indicator for natural gas combustion was the total natural gas consumption for commercial uses as reported in Reference 1.

3.11.3   Emission Factor

The emission factors for all pollutants except PM-10 for the combustion of natural gas (SCC 1-03-006-03) were obtained from Reference 2a. The PM-10 emission factor was obtained from Reference 3.

3.11.4   Control Efficiency

The PM-10 control efficiencies for the years 1975 through 1984 were equal to the 1988 PM-10 control efficiency obtained from Reference 4. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions from natural gas combustion.

No control efficiencies were applied to the activity data to estimate CO, NO_x, SO_2, TSP, or VOC emissions from this source.

3.11.5   References

1. *Natural Gas Annual*. DOE/EIA-0131(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.

2. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
    a.   Volume I, Table 1.4-1

3. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listings for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

4. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.

3.12   FUEL COMBUSTION OTHER - RESIDENTIAL WOOD: 03-05

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source category.

Tier I Category   Tier II Category

(03) FUEL COMBUSTION -   (05) Residential Wood
      OTHER

3.12.1   Technical Approach

The CO, NO_x, PM-10, TSP, SO_2, and VOC emissions included in this Tier category were the emissions from the source category listed above. Emissions were estimated from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, the activity indicator was expressed in thousand short tons and the emission factors were expressed in metric pounds/short ton.

The procedures for determining activity indicators and emission factors were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\text{-}10 \ Emissions_{year} \ = \ PM\text{-}10 \ Emissions_{1975} \times \frac{TSP \ Emissions_{year}}{TSP \ Emissions_{1975}} \qquad \text{(Eq. 3.12-1)}$$

This calculation was used in place of estimating the emissions based on activity indicators and emission factors.

3.12.2   Activity Indicator

The activity indicator for the residential combustion of wood was based on the consumption of wood for residential combustion as reported in Reference 1. It was assumed that 15 percent of the heating value is lost to moisture on a typical basis. Therefore, the reported consumption figure was multiplied by 0.85 to obtain the activity indicator. Alternatively, the procedure used to determine the emission factors for this category was used to estimate residential wood consumption as described below in section 3.12.3. The wood consumption calculated by this method was normalized to the total wood consumption reported by the Department of Energy (no reference for this value is currently available).

3.12.3   Emission Factor

The emission factors for the residential burning of wood were the weighted average of the emission factors for wood burned in wood stoves and in fireplaces. These emission factors for all pollutants except PM-10 and TSP obtained from References 2a and 2b for wood stoves and fireplaces, respectively. The PM-10 and TSP emission factors were obtained from Table 3.1-3 of this report. Weighting factors were based on the relative quantity of wood burned in wood stoves and in fireplaces. Weighting factors of 0.755 for wood stoves and 0.245 for fireplaces were used when the factors were not determined as described below.

The quantity of wood consumed in fireplaces was determined from the number of fireplaces obtained from Reference 3a and the assumption that on average one-half cord of wood is burned in each fireplace per year. The calculation, including the necessary conversion factors is shown in Equation 3.12-2.

$$Wood\ Consumption_{fireplaces} = N_{fireplaces} \times \frac{0.5\,cord}{yr} \times \frac{4\,m^3}{cord} \times \frac{0.028317\,ft^3}{m^3} \times \frac{35\,lb}{ft^3} \times \frac{1\,ton}{2,000\,lb} \text{(Eq. 3.12-2)}$$

The quantity of wood burned in wood stoves was determined from the number of wood stoves and the stove heat input rates. The number of wood stoves being used in a given year was calculated as the number of stoves being used in the previous year, the number of new shipments of stoves, and the number of obsolete stoves as summarized in Equation 3.12-3.

$$N_{Wood\ Stoves,\ i} = N_{Wood\ Stoves,\ i-1} + N_{New\ Wood\ Stoves,\ i} - N_{New\ Wood\ Stoves,\ i-6} \qquad \text{(Eq. 3.12-3)}$$

where   i   =   year under study

The total shipments and imports of stoves was obtained from Reference 4. It was assumed that for the years 1981 through 1984, the number of shipments remained constant at the 1981 value. The number of obsolete stoves was assumed to be the number of stove shipments from the sixth previous year.

The total number of wood stoves in use was divided into two categories: primary and secondary. The number of primary stoves was extrapolated from the previous year's number based on the relative change in the number of dwelling units using wood as the primary house heating fuel obtained from Reference 3. The number of secondary stoves was calculated as the difference between the total number of wood stoves and the number of primary stoves.

The stove heat input rate for each stove type was used to calculate the total energy consumed by each stove type. The 1984 stove heat input rates for primary and secondary stoves were 112,453 x 10^6 Btu and 42.37 x 10^6 Btu, respectively. No reference is currently available for this value and it is not known at this time if year-specific heat input rates were used for the year prior to 1984. The total energy consumed by the primary and secondary wood stoves were summed and converted to the quantity of wood consumed using the factor 17.2 x 10^6 Btu/ton.

The total quantity of wood consumed by residential combustion was calculated as the sum of the quantity of wood consumed in fireplaces and in wood stoves. The relative quantities of wood consumed

by fireplaces and wood stoves were calculated and used as the weighting factors for determining the emission factors for this source category.

3.12.4 Control Efficiency

No control efficiencies were applied to the activity data to estimate the emissions from the residential combustion of wood.

3.12.5 References

1. *Estimates of U.S. Biofuels Consumption*. SR/CNEAF/91-02. Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.

2. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
   (a) Volume I, Table 1.10-1, Supplement D, September 1991, Supplement C, September 1990, or Supplement B, September 1988.
   (b) Volume I, Table 1.9-1, Supplement D, September 1991

3. *American Housing Survey, Current Housing Reports, Series H-150-83*. Bureau of the Census, U.S. Department of Commerce, Washington DC. Biennial.
   (a) Table 2-4, Selected Equipment and Plumbing - Occupied Units

4. *Estimates of U.S. Wood Energy Consumption from 1949 to 1981*. DOE/EIA-0341. Energy Information Administration, U.S. Department of Energy, Washington, DC. August 1982.

3.13   FUEL COMBUSTION OTHER - RESIDENTIAL OTHER: 03-06

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source categories.

Tier I Category	Tier II Category	Tier II Subcategory
(03) FUEL COMBUSTION - OTHER	(06) Residential Other	Anthracite Coal Bituminous, Subbituminous, and Lignite Coal Residual Oil Distillate Oil Natural Gas Liquid Petroleum Gas Kerosene

3.13.1   Technical Approach:

The CO, NO_x, PM-10, TSP, SO_2, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, the activity indicator for bituminous, subbituminous, and lignite coal was expressed in million short tons and the emission factors were expressed in metric pounds/short ton. The activity indicator for anthracite coal was expressed in thousand short tons and the emission factors were expressed in metric pounds/short ton. For residual and distillate oil, kerosene, and LPG, activity indicators were expressed in million gallons and emission factors were expressed in metric pounds/thousand gallons. The activity indicator for natural gas was expressed in billion cubic feet and the emission factors were expressed in metric pounds/million cubic feet. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to Equation 3.13-1.

$$PM\text{-}10\ Emissions_{year}\ =\ PM\text{-}10\ Emissions_{1975}\ \times\ \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}} \qquad \text{(Eq. 3.13-1)}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.13.2   Activity Indicator:

The activity indicator for anthracite coal combustion was the residential consumption of anthracite coal. This value was determined by extrapolating residential consumption of anthracite coal for the previous year based on the change in the number of dwelling units in the Northeastern United States having coal as the main fuel for space heating. Data concerning the number of dwelling units was obtained from Reference 1. The calculation of the residential anthracite coal consumption is summarized in Equation 3.13-2.

$$Anthracite\ Coal_{R,\ i}\ =\ Anthracite\ Coal_{R,\ i-1}\ \times\ \frac{Dwelling\ Units_i}{Dwelling\ Units_{i-1}} \qquad \text{(Eq. 3.13-2)}$$

where: R   =   residential consumption
         i   =   year under study

The activity indicator for bituminous, subbituminous, and lignite coal combustion was the residential consumption of bituminous, subbituminous, and lignite coal. This value was determined by estimating the quantity of all coal consumed by all dwelling units using coal as the main fuel and subtracting from this value the residential consumption of anthracite coal calculated above. The quantity of all coal consumed was calculated using the number of dwelling units using coal as the main fuel for space heating obtained from Reference 1 and a factor estimating the average annual consumption of coal per dwelling unit. This calculation is summarized in Equation 3.13-3.

$$Bituminous\ Coal_{R,i}\ =\ (Dwelling\ Units_i\ \times\ 6.73\ tons\ burned/dwelling/year)\ -\ Anthracite\ Coal_{R,i} \qquad \text{(Eq. 3.13-3)}$$

where: R   =   residential consumption
         i   =   year under study

The activity indicator for the residential combustion of residual oil was assumed to be zero.

The activity indicator for distillate oil combustion was the sum of the "adjusted" sales (or deliveries) for residential use of distillate oil and for farm use of other distillates as reported in Reference 2 or Reference 3.

The activity indicator for natural gas combustion was the total natural gas consumption for residential use obtained from Reference 4.

The activity indicator for kerosene combustion was the quantity of kerosene sales. This value was obtained by summing sales figures reported for the residential, commercial, and farm use categories as reported in Reference 2 or Reference 3.

The activity indicator for LPG combustion was based on the 1982 total residential sales of LPG ($4,047 \times 10^6$ gal). This value was extrapolated to the year under study based on the relative change in the LPG products supplied from the year 1982 (1499×10^3 bbl/day) to the year under study. Quantities of LPG products supplied for the specific years were obtained from Reference 5. Equation 3.13-4 summarizes this calculation.

$$Residential\ Sales_{LPG,\ i} = Residential\ Sales_{LPG,\ 1982} \times \frac{Products\ Supplied_{LPG,\ i}}{Products\ Supplied_{LPG,\ 1982}} \quad \text{(Eq. 3.13-4)}$$

where: i   =   year under study

3.13.3   Emission Factors:

The emission factors for residential anthracite coal combustion (SCC 10300103, hand-fired units) were obtained from Reference 6a for all pollutants except PM-10. The PM-10 emission factor was obtained from Reference 7. The PM-10 and TSP factors were multiplied by an ash content of 11 percent. The SO_2 factor was multiplied by a sulfur content value of 0.7 percent.

The emission factors for all pollutants except PM-10 for the combustion of bituminous coal and lignite (SCC 10300103, hand-fired units) were obtained from Reference 6b. The PM-10 emission factor was obtained from Reference 7.

The SO_2 emission factor was multiplied by the average sulfur content for all coal used by commercial users. The average sulfur content of coal was determined from the sulfur content by coal producing districts obtained for the category "All other uses" in Reference 8a. This reference provided the sulfur content values reported in 1977 and it was assumed that these values remained constant during the years 1940 through 1984. In order to obtain the average sulfur content for a specific year, the sulfur content by district was weighted by the distribution of coal by district of origin for the category "Commercial and Residential" obtained from Reference 9a or Reference 10.

No emission factors were required for residential residual oil combustion, because the activity was assumed to be zero.

The emission factors for the combustion of distillate oil were obtained from Reference 6c under the classification residential furnaces for all pollutants except PM-10. The PM-10 emission factor was obtained from Reference 7 or Table 3.1-3 of this report. The SO_2 emission factor was multiplied by the weighted average sulfur content. Sulfur contents for No. 1 and No. 2 oils were obtained from Reference 11. Weighting factors were the corresponding quantity of sales (or deliveries) to residential users as reported in Reference 2 or Reference 3. The resulting weighted average sulfur content was applied to the SO_2 emission factor.

The emission factors for all pollutants except PM-10 for natural gas combustion (SCC 1-03-006-03) were obtained from Reference 6d. The PM-10 emission factor was obtained from Reference 7.

The emission factors for residential kerosene combustion were obtained from Reference 6c under the classification residential furnace for distillate oil for all pollutants except PM-10. The PM-10 emission

factor was obtained from Reference 7 or Table 3.1-3 of this report. The SO_2 emission factor was multiplied by a sulfur content of 0.075 percent.

The emission factors for LPG combustion were obtained from Reference 6e under the classification domestic/commercial for all pollutants except PM-10. The PM-10 emission factor was obtained from Reference 7. The SO_2 emission factor was multiplied by a sulfur content of 0.0013 percent.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier II category.

3.13.4   Control Efficiency

No control efficiencies were applied to the activity data to estimate CO, NO_x, SO_2, TSP, and VOC emissions from the sources included in this Tier II category.

For the residential combustion of anthracite coal, bituminous coal and lignite, natural gas, and LPG, the PM-10 control efficiencies for the years 1975 through 1984 were equal to the 1988 PM-10 control efficiencies obtained from Reference 12. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions from the combustion of these fuels. For the residential combustion of residual oil, distillate oil, and kerosene, no control efficiencies were applied to the activity data to estimate PM-10 emissions.

3.13.5   References

1. *American Housing Survey, Current Housing Reports, Series H-150-83*. Bureau of the Census, U.S. Department of Commerce, Washington DC. Biennial.

2. *Petroleum Marketing Annual*. DOE/EIA-0389(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.

3. *Fuel Oil and Kerosene Sales 19xx*. DOE/EIA-0535(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.

4. *Natural Gas Annual*. DOE/EIA-0131(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.

5. *Petroleum Supply Annual*. DOE/EIA-0340(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.

6. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
    (a) Volume I, Table 1.2-1, Supplement B, September 1988.
    (b) Volume I, Table 1.1-1
    (c) Volume I, Table 1.3-1
    (d) Volume I, Table 1.4-1
    (e) Volume I, Table 1.5-1

7. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listings for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

8. *Coal Production*. DOE/EIA-0118(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
    (a) Table entitled, "Shipments of bituminous coal and lignite by district, consumer, use, and average sulfur content - 1977."

9. *Coal Distribution January-December 19xx*. DOE/EIA-0125(xx/4Q). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
    (a) Table entitled, "Domestic Distribution of U.S. Coal to the Residential and Commercial Sector by Origin."

10. *Minerals Yearbook*, Coal. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.

11. *Heating Oils*. U.S. Department of Energy. Obtainable from the National Institute for Petroleum and Energy Research, ITT Research Institute, P.O. Box 2128, Bartlesville, OK. Annual.

12. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.

**3.14   CHEMICAL AND ALLIED PRODUCT MANUFACTURING - ORGANIC
        CHEMICAL MANUFACTURING: 04-01**

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source categories.

Tier I Category	Tier II Category	Tier II Subcategory
(04) CHEMICAL AND ALLIED PRODUCT MANUFACTURING	(01) Organic Chemical Manufacturing	Petrochemicals excluding storage and handling and waste disposal Charcoal (NO$_x$ and VOC)

3.14.1   Technical Approach

The CO, NO$_x$, PM-10, TSP, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in thousand short tons and emission factors were expressed in metric pounds/short ton. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to Equation 3.14-1.

$$PM\text{-}10 \ Emissions_{year} \ = \ PM\text{-}10 \ Emissions_{1975} \ \times \ \frac{TSP \ Emissions_{year}}{TSP \ Emissions_{1975}} \qquad \text{(Eq. 3.14-1)}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.14.2   Activity Indicator

3.14.2.1 CO Emissions

The activity indicator for charcoal manufacturing was the production figure for charcoal obtained from Reference 1.

The activities indicators for petrochemical manufacturing were the production figures for each material. Production numbers for acetic acid, dimethyl terephthalate, ethylene dichloride, formaldehyde, maleic anhydride were obtained from Reference 2 or Reference 3. Total production of acrylonitrile and phthalic anhydride was obtained from Reference 2. The production level of cyclohexanone was obtained from Reference 3. The approximate production of cyclohexanol was accounted for by multiplying the cyclohexanone production level by 2. If Reference 3 was not available, the adipic acid production was obtained from Reference 2. It was assumed that the cyclohexanol/none production reported in Reference 4 for the previous year changed in direct proportion to adipic acid production.

3.14.2.2 NO$_x$ Emissions

The activity indicator for charcoal manufacturing was the production figure for charcoal obtained from Reference 1.

The activities indicators for petrochemical manufacturing were the production figures for each material. Total production levels of acrylonitrile and adipic acid were obtained from Reference 2. In order to determine the adiponitrile production level, the total nylon production was obtained from Reference 2. It was assumed that the year-to-year change in nylon production was proportional to year-to-year change in adiponitrile production.

3.14.2.3 PM-10 and TSP Emissions

The activity indicators for petrochemical manufacturing were the production figure for each material. Production levels of phthalic anhydride, polyethylene, PVC, and polypropylene were obtained from Reference 2.

3.14.2.4 VOC Emissions

The activity indicators for petrochemical manufacturing processes, excluding the storage and handling and waste disposal, were the production figures for each material. Production numbers for the chemicals listed in Table 3.14-1 were obtained from Reference 2 or Reference 3. Activity indicators for the other products and fugitive subcategories were based on the industrial organic chemical production index obtained from Reference 2.

The activity indicator for charcoal manufacturing was the production figure for charcoal obtained from Reference 1.

3.14.3   Emission Factor

3.14.3.1 CO Emissions

The emission factor for charcoal (SCC 3-01-006-01) was obtained from Reference 5a.

The emission factors for acetic acid, acrylonitrile, cyclohexanol/none and ethylene dichloride, formaldehyde, and phthalic anhydride were obtained from Reference 6. The emission factor for dimethyl

terephthalate (SCC 3-01-031-01) was obtained from Reference 5b. The emission factor for maleic anhydride (SCC 3-01-100-02) was obtained from Reference 5c.

3.14.3.2 NO$_x$ Emissions

The emission factor for charcoal (SCC 3-01-006-01) was obtained from Reference 5a.

The emission factors for acrylonitrile and adiponitrile were obtained from Reference 7. The emission factor for the adipic acid (SCC 3-01-001-01) was obtained from Reference 5d.

3.14.3.3 PM-10 and TSP Emissions

The emission factors for phthalic anhydride were determined from the emission factors for the raw material inputs of: o-xylene or naphthalene. The emission factors for o-xylene (SCC 3-01-019-02, 3-01-019-02, and 3-01-019-04) and for naphthalene (SCC 3-01-019-05, 3-01-019-06, and 3-01-019-07) were obtained from Reference 5f for TSP and from Reference 8 for PM-10. These emission factors were weighted according to the capacity figures in Reference 9, in which a table showed the capacity of phthalic anhydride production in the United States by raw material input: o-xylene or naphthalene.

The emission factors for polyethylene were the averages of the emission factors for the SCCs 3-01-018-07 and 1-01-018-12. The TSP emission factors were obtained from Reference 7 and the PM-10 emission factors were obtained from Reference 8. Emission factors for the PVC (SCC 3-01-018-01) and polypropylene (SCC 3-01-018-02) were obtained from Reference 5e for TSP and from Reference 8 for PM-10.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier II category.

3.14.3.4 VOC Emissions

The emission factors for the chemical products listed in Table 3.14-1 were obtained from Reference 10, with the exception of the emission factors for acetic acid, acrylic acid and acrylonitrile which were obtained from Reference 11. Weighted average emission factors for the chemical products where more than one SCC was listed were calculated using the weighting factors given in Table 3.14-1. Where no weighting factors were given, the overall emission factor for the chemical product was the sum of the emission factors for the SCCs listed.

For the years 1940 through 1976, the VOC emission factors for other products and fugitives were obtained from Reference 12. The emission factors for the years 1982 through 1984 were obtained from Reference 6. The emission factors for the intervening years of 1977 through 1983 were derived from a linear interpolation between the values for the years 1976 and 1982.

The emission factor for charcoal (SCC 3-01-006-01) was obtained from Reference 5a.

3.14.4   Control Efficiency

3.14.4.1 CO Emissions

The control efficiency for charcoal manufacturing was derived from Reference 13 or Reference 14 using Equation 3.14-2.

$$CE \quad = \quad \left[\frac{(UE - AE)}{UE} \right]$$

(Eq. 3.14-2)

where: CE =   control efficiency
UE =   emissions before control
AE =   emissions after control

No control efficiencies were applied to the activity data to estimate emissions from petrochemical production.

3.14.4.2 NO$_x$ Emissions

No control efficiencies were applied to the activity data to estimate NO$_x$ emissions from charcoal and petrochemical production.

3.14.4.3 PM-10 and TSP Emissions

The TSP control efficiency for PVC production was derived from Reference 13 or Reference 14 using the same equation given above for the CO control efficiency for charcoal.

The TSP control efficiency for phthalic anhydride production was assumed to have a constant value of 0.85 for the years 1979 through 1984. The procedure used to determine the control efficiencies for the years 1940, 1950, 1960, and 1970 through 1978 is currently unavailable.

No control efficiencies were applied to the activity data to estimate TSP emissions from polyethylene and polypropylene production.

The PM-10 control efficiencies for the petrochemical emission sources for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 15. During these years, any changes in the corresponding TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate the PM-10 emissions.

3.14.4.4 VOC Emissions

The control efficiency for charcoal manufacturing was derived from Reference 13 or Reference 14 using the same equation given above for the CO control efficiency. No control efficiencies were applied to the activity data to estimate VOC emissions from the petrochemical manufacturing sources included in this Tier II category.

3.14.5 References

1. *Census of Manufactures*. Bureau of the Census, U.S. Department of Commerce, Washington, DC. Available every 5 years.

2. *Chemical and Engineering News, Facts and Figures Issue*. American Chemical Society, Washington, DC. Annual.

3. *Synthetic Organic Chemicals, United States Production and Sales*. USITC Publication 1745. U.S. International Trade Commission, Washington, DC. Annual.

4. *OAQPS Data File on National Emissions*. National Air Data Branch, U.S. Environmental Protection Agency, Research Triangle Park, NC. 1984.

5. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
   a.   Volume I, Table 5.4-1
   b.   Volume I, Table 5.21-1
   c.   Volume I, Table 5.24-1
   d.   Volume I, Table 5.1-1
   e.   Volume I, Table 5.13-1
   f.   Volume I, Table 5.12-1

6. *Control Techniques for VOC Emissions from Stationary Sources*. 450/3-85-008. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1985.

7. *Survey Reports on Atmospheric Emissions from the Photochemical Industry, Volume IV*. EPA-450/3-73-005-d. U.S. Environmental Protection Agency, Research Triangle Park, NC. April 1974.

8. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listing for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

9. Directory of Chemical Producers

10. *VOC Emission Factors for the NAPAP Emission Inventory*. Draft Document. U.S. Environmental Protection Agency. Prepared by Radian Corporation for Air and Energy Engineering Research Laboratory. August 1986.

11. Criteria Pollutant Emission Factors for the 1985 NAPAP Emission Inventory.

12. *Organic Chemical Manufacturing, Volume 1: Program Report*. EPA-450/3-80-023. U.S. Environmental Protection Agency, Research Triangle Park, NC. December 1980.

13. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem.* Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

14. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS).* Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

15. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.

Table 3.14-1. Chemical Products, SCCs, and Weighting Factors for VOC Emission Factors

Chemical Product	SCC	Weighting Factor

Acetic acid*   - via Methanol
        - via Butane
        - via Acetaldehyde
	3-01-132-01
	3-01-132-05
	3-01-132-10
		0.43
		0.28
		0.29

Acrylic acid*	3-01-132-21	
Acrylonitrile*	3-01-245-05	
Adiponitrile via Butadiene	3-01-254-10	
Benzene - Reactor - Distillation Vent	3-01-258-02 3-01-258-03	
Butadiene & Butylene Fractions	3-01-153-10(20)	
1,3 Butadiene	3-01-153-10(20)	
Caprolactam	3-01-210-02 3-01-210-03 3-01-210-05 3-01-210-06 3-01-210-07 3-01-210-08 3-01-210-09 3-01-210-10	
Chlorobenzene	3-01-301-10	
Cyclohexanone	3-01-158-01	
Cumene	3-01-156-01	
Dimethyl Terephthalate	3-01-031-01	
Ethyl Benzene	3-01-169-01	
Ethylene	3-01-197-41 3-01-197-43 3-01-197-45	
Ethylene Dichloride - oxychlorination - Direct chlorination	3-01-125-01 3-01-125-02	0.996 0.004
Ethylene Glycol	3-01-251-02 3-01-251-03	
Ethylene Oxide	3-01-174-01	
Formaldehyde - Silver Catalyst - Mixed Oxide Catalyst	3-01-120-01 3-01-120-02	0.8 0.2
Linear Alkylbenzene - Olefin process - Chlorination Process	3-01-211-02 3-01-211-03 3-01-211-04 3-01-211-22 3-01-211-23 3-01-211-24 3-01-211-25	0.36 0.36 0.36 0.64 0.64 0.64 0.64

Table 3.14-1. (continued)

Chemical Product	SCC	Weighting Factor
Maleic Anhydride	3-01-100-02 3-01-100-03 3-01-100-05	
Methanol	3-01-250-02 3-01-250-03	
Methyl Methacrylate	3-01-190-02 3-01-190-03 3-01-190-04 3-01-190-10 3-01-190-11 3-01-190-12 3-01-190-13 3-01-190-14	
Nitrobenzene	3-01-195-01	
Perchloroethylene	3-01-125-20	
Phenol	3-01-202-01	
Propylene Oxide - Chlorohydrin - Isobutane - Ethylbenzene	3-01-205-** 3-01-205-** 3-01-205-**	0.53 0.33 0.14
Styrene	3-01-206-01	
Toluene Diisocyanate	3-01-181-02 3-01-181-03 3-01-181-04 3-01-181-05 3-01-181-06 3-01-181-07 3-01-181-08	
Vinyl Acetate	3-01-167-02 3-01-167-03 3-01-167-04	
Vinyl Chloride	3-01-125-40	

* The emission factors for these chemical products were obtained from Reference 10. For all other chemical products, the emission factors were obtained from Reference 9.

3.15 CHEMICAL AND ALLIED PRODUCT MANUFACTURING - INORGANIC CHEMICAL MANUFACTURING: 04-02

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source categories.

Tier I Category	Tier II Category	Tier II Subcategory
(04) CHEMICAL AND ALLIED PRODUCT MANUFACTURING	(02) Inorganic Chemical Manufacturing	Ammonia Titanium Dioxide Nitric Acid Calcium Carbide Sulfuric Acid

3.15.1 Technical Approach

The CO, NO_x, PM-10, TSP, SO_2, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in thousand short tons and emission factors were expressed in metric pounds/short ton. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to Equation 3.15-1.

$$PM\text{-}10\ Emissions_{year}\ =\ PM\text{-}10\ Emissions_{1975}\ \times\ \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}} \qquad \text{(Eq. 3.15-1)}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.15.2   Activity Indicator

3.15.2.1 CO Emissions

The activity indicator for ammonia was the total quantity of ammonia production obtained from Reference 1. The activity indicator for titanium dioxide was based on the total quantity of titanium dioxide production as reported in Reference 1. It was assumed that 73 percent of total production was by chloride process. Therefore total production was multiplied by 0.73 to calculate the total titanium dioxide produced by the chloride process. For a more accurate figure for the percentage of production by the chloride process, Reference 2 should be consulted.

3.15.2.2 NO_x Emissions

The activity indicator for ammonia was the total quantity of ammonia production obtained from Reference 1. The activity indicator for nitric acid was the total production of nitric acid obtained from Reference 1.

3.15.2.3 PM-10 and TSP Emissions

The activity indicator for calcium carbide was the total production of calcium carbide obtained from Reference 3. When data was withheld (i.e., for proprietary reasons), the previous year's data was used. The activity indicator for sulfuric acid was the total production of sulfuric acid obtained from Reference 3.

3.15.2.4 SO_2 Emissions

The activity indicator for sulfuric acid was the total production of sulfuric acid obtained from Reference 3.

3.15.2.5 VOC Emissions

The activity indicator for ammonia was the total quantity of ammonia production was obtained from Reference 1.

3.15.3   Emission Factor

3.15.3.1 CO Emissions

The emission factor for ammonia was the sum of emission factors for feedstock desulfurization (SCC 3-01-003-05), primary reformer, natural gas (SCC 3-01-003-06), and CO regenerator (SCC 3-01-003-08). These emission factors were obtained from Reference 4a. The emission factor for titanium dioxide was obtained from Reference 5 for all U.S. plants with actual CO emission source tests (SCC = 3-03-012-01).

3.15.3.2 NO_x Emissions

The emission factor for ammonia (SCC 3-01-003-06) was obtained from Reference 4a.

The emission factor for nitric acid was the weighted average of the emission factors for nitric acid production by old plants (43 lb/ton) and new plants (3 lb/ton). The weighting factors used to calculate the overall emission factor were the percentage of production from old plants and from new plants, respectively. New plant production was equal to 5 percent of the total 1970 production (380,000 tons) for each year since 1970. Old plant production was equal to the difference between total production as reported in Reference 1 and new plant production, as calculated above.

3.15.3.3 PM-10 and TSP Emissions

The PM-10 and TSP emission factors for calcium carbide were the sum of three emission factors: electric furnace (SCC 3-05-004-01), coke dryer (SCC 3-05-004-02) and furnace room vents (SCC 3-05-004-03). The TSP emission factors were obtained from Reference 4c and the PM-10 emission factors were obtained from Reference 9. The emission factors for sulfuric acid (SCC 3-01-023-01) were obtained from Reference 4b for TSP and from Reference 6 for PM-10.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier II category.

3.15.3.4 SO_2 Emissions

The emission factors for sulfuric acid were based on the emission factor calculated for the year previous to the year under study and the NSPS emission factor (4 lb/ton). The weighted average of these two emission factors was based on the production levels for the year under study and the previous year as presented in Equation 3.15-2.

$$EF_i = \frac{(0.95 \times EF_{i-1} \times P_{i-1}) + (0.05 \times EF_{NSPS} \times P_{i-1}) + ((P_i - P_{i-1}) \times EF_{NSPS})}{P_i}$$ (Eq. 3.15-2)

where: EF = SO_2 emission factor
         i = year under study
        P = total production

When the production for the year under study was less than the production for the previous year, then the last term $(P_i - P_{i-1})$ was set to zero. New capacity for production was only assumed for a production level above the previous record high production level.

3.15.3.5 VOC Emissions

The emission factor for ammonia was the sum of emission factors for feedstock desulfurization (SCC 3-01-003-05), primary reformer, natural gas (SCC 3-01-003-06), carbon dioxide regenerator (SCC 3-01-003-08), and condensate stripper (SCC 3-01-003-09). These emission factors were obtained from Reference 4a.

3.15.4   Control Efficiency

No control efficiencies were applied to the activity data to estimate CO, NO$_x$, SO$_2$, and VOC emissions from the source included in this Tier II category.

The TSP control efficiencies for sulfuric acid and calcium carbide production were derived from Reference 7 or Reference 8 using Equation 3.15-3.

$$CE \quad = \quad \left[\frac{(UE - AE)}{UE} \right] \qquad \text{(Eq. 3.15-3)}$$

where: CE =   control efficiency
           UE =   emissions before control
           AE =   emissions after control

The PM-10 control efficiencies for sulfuric acid and calcium carbide production for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 9. During these years, any changes in the corresponding TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate the PM-10 emissions.

3.15.5   References

1. *Chemical and Engineering News, Facts and Figures Issue*. American Chemical Society, Washington, DC. Annual.

2. *Chemical Economics Handbook*. Stanford Research Institute International, Menlo Park, CA.

3. *Current Industrial Reports*, Inorganic Chemicals. Bureau of the Census, U.S. Department of Commerce, Washington, DC. Annual.

4. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
    a.   Volume I, Table 5.2-1
    b.   Volume I, Table 5.17-2
    c.   Volume I, Table 8.4-1

5. *Computer Retrieval, NE257 report, by Source Classification Code (SCC) from the National Emission Data System (NEDS)*. Unpublished computer report. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. February 9, 1980.

6. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listings for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

7. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem.* Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

8. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS).* Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

9. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.

3.16   CHEMICAL AND ALLIED PRODUCTS MANUFACTURING - POLYMER AND RESIN MANUFACTURING: 04-03

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source categories.

Tier I Category	Tier II Category	Tier II Subcategory
(04) CHEMICAL AND ALLIED PRODUCT MANUFACTURING	(03) Polymer and Resin Manufacturing	Plastics Manufacturing excluding fabrication Synthetics Fibers and Rubber

3.16.1   Technical Approach

The VOC emissions included in this category were the sum of the emissions from the source categories listed above. Emissions were estimated only for VOC from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in thousand short tons and emission factors were expressed in metric pounds/short ton. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984.

3.16.2   Activity Indicator

The activity indicators for plastics manufacture were the total production levels for each material. The total production levels of high density polyethylene, low density polyethylene, polypropylene, and polyvinyl chloride were obtained from Reference 1. The production level of polystyrene was obtained from Reference 1 as the sum of production levels for the following substances: (1) styrene-acrylonitrile, (2) polystyrene, and (3) acrylonitrile-butadiene-styrene and other styrene polymers. The production level for other plastics was obtained from Reference 1 as the sum of production levels for the following substances: (1) thermosetting resins, (2) polyamides, and (3) other vinyl resins.

The activity indicator for synthetic fibers was the quantity of total man-made fiber production obtained from Reference 1. The activity indicator for the total synthetic rubber subcategory was the production of synthetic rubber obtained from Reference 1.

3.16.3   Emission Factor

The emission factors for high density polyethylene (SCC 3-01-018-07), low density polyethylene (SCC 3-01-018-12), and polystyrene (SCC 3-01-01801) were obtained from Reference 2. The emission factors for polypropylene (SCC 3-01-018-02) and polyvinyl chloride (SCC 3-01-018-01) were obtained from Reference 3a.

The emission factor for other plastics manufacturing was calculated by dividing the 1979 actual emissions for this source by the corresponding activity indicator. The calculation of the 1979 actual emissions for other plastics followed the steps described below.

1. The 1979 total actual emissions for the high density polyethylene, low density polyethylene, polypropylene and polystyrene subcategories were calculated using the corresponding 1979 activity indicators and emission factors.

2. The 1979 actual emissions of polyethylene terephthalate were added to the previous sum. Actual emissions of polyethylene terephthalate were estimated by multiplying the emission factor obtained from Reference 4 by the production level obtained from Reference 1 for 1979.

3. It was assumed that the sum calculated in step 2 represented 75 percent of the total emissions from all plastics. Therefore, the total emissions from all plastics in 1979 was calculated by dividing the total from step 2 by 0.75.

4. The 1979 actual emissions of high density polyethylene, low density polyethylene, polypropylene and polystyrene were subtracted from the total emission from all plastics calculated in step 3. The result was the total 1979 emissions from the other plastics category.

The emission factors for synthetic fibers was obtained from Reference 5. The emission factor for synthetic rubber was the weighted average of emission factors for the following compounds: polychloroprene, polyisoprene, butyl, nitrile, polybutadiene, ethylene propylene copolymers, styrene butadiene rubber, and "others." The styrene butadiene rubber emission factor was obtained from Reference 3a and all other emission factors were obtained from Reference 6. These emission factors were weighted by the relative quantity of each compound produced in 1979 as obtained from Reference 1.

3.16.4   Control Efficiency

Control efficiencies were applied to the activity data to estimate VOC emissions from high density polyethylene production processes, but the procedures for determining these control efficiencies are currently unavailable. No control efficiencies were applied to the activity data to estimate emissions from all other sources included in this Tier II category.

3.16.5   References

1. *Chemical and Engineering News, Facts and Figures Issue*. American Chemical Society, Washington, DC. Annual.

2. Criteria Pollutant Emission Factors for the 1985 NAPAP Emissions Inventory.

3. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
   a.   Volume I, Table 5.13-1

4. *Polymer Manufacturing Industry - Background Information for Proposed Standards; Preliminary Draft*. EPA-450/3-83-012a. U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1984.

5. *OAQPS Data File on National Emissions*. National Air Data Branch, U.S. Environmental Protection Agency, Research Triangle Park, NC. 1984.

6. *Control Techniques for VOC Emissions from Stationary Sources*. EPA-450/3-85-008. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1985.

3.17   CHEMICAL AND ALLIED PRODUCT MANUFACTURING - AGRICULTURAL CHEMICAL MANUFACTURING: 04-04

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source category.

Tier I Category	Tier II Category	Tier II Subcategory
(04) CHEMICAL AND ALLIED PRODUCT MANUFACTURING	(04) Agricultural Chemical Manufacturing	Fertilizers - ammonia nitrate, diammonium phosphate and urea

3.17.1   Technical Approach

The PM-10 and TSP emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were only estimated for particulate matter from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in thousand short tons and emission factors were expressed in metric pounds/short ton. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1992 for TSP and for the years 1975 through 1984 for PM-10. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to Equation 3.17-1.

$$PM\text{-}10 \ Emissions_{year} \ = \ PM\text{-}10 \ Emissions_{1975} \ \times \ \frac{TSP \ Emissions_{year}}{TSP \ Emissions_{1975}} \qquad \text{(Eq. 3.17-1)}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.17.2   Activity Indicator

The activity indicators for the manufacture of fertilizers were the production levels of the individual materials. Total production levels for ammonium nitrate and urea were obtained from Reference 1. Total production of diammonium phosphate was calculated as the sum of production levels of diammonium, monoammonium, and other ammonium phosphates obtained from Reference 2. Production was expressed in equivalent tons of phosphoric oxide, P_2O_5 content.

3.17.3   Emission Factor

The emission factors for ammonium nitrate manufacturing were the weighted averages of the emission factors for specific processes obtained from Reference 3a for TSP and from Reference 4 for PM-10. The specific processes and SCCs included in the weighted averages along with the weighting factors are presented in Table 3.17-1. Each emission factor was multiplied by the corresponding weighting factor and the products were summed.

The emission factors for diammonium phosphate production were the sum of the emission factors for following processes: (1) dryer, cooler and (2) ammoniator - granulator. The TSP emission factors were obtained from Reference 5a; the PM-10 emission factors were obtained from Reference 4.

For urea production, the emission factors were the weighted averages of emission factors for specific processes obtained from Reference 3b for TSP and from Reference 4 for PM-10. The specific processes and SCCs included in the weighted averages along with the weighting factors are presented in Table 3.17-2. Each emission factor was multiplied by the corresponding weighting factor and the products were summed.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier II category.

3.17.4   Control Efficiency

The TSP control efficiency for diammonium phosphate production was derived from Reference 6 or Reference 7 using Equation 3.17-2.

$$CE \quad = \quad \left[\frac{(UE - AE)}{UE} \right] \qquad \text{(Eq. 3.17-2)}$$

where: CE = control efficiency
         UE = emissions before control
         AE = emissions after control

The TSP control efficiencies for ammonium nitrate and urea production were based on the controlled and uncontrolled emission factors from Reference 1. For ammonium nitrate production, this procedure for determining control efficiency was used for the years 1974 through 1984. For urea production, this procedure was used for the years 1979 through 1984. For the years prior to those stated above, the procedures for determining the TSP control efficiencies are currently unavailable.

The PM-10 control efficiencies for the production of these three fertilizers for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 8. During these years, any changes in the corresponding TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

3.17.5   References

1. *Chemical and Engineering News, Facts and Figures Issue.* American Chemical Society, Washington, DC. Annual.

2. *Current Industrial Reports*, Fertilizer Materials. Bureau of the Census, U.S. Department of Commerce, Washington, DC. Annual.

3. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42.* U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
    a. Volume I, Table 6.8-1
    b. Volume I, Table 6.14-1

4. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listing for Criteria Air Pollutants.* EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

5. *Compilation of Air Pollutant Emission Factors, Third Edition, Supplements 1 through 14, AP-42.* NTIS PB-275525. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1977.
    b. Volume I, Table 6.10-1

6. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem.* Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

7. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS).* Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

8. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.

Table 3.17-1. Ammonium Nitrate Emission Factor SCCs and Weighting Factors

SCC	Description	Weighting Factor
3-01-027-04	Neutralizer (All Plants)	1.0
3-01-027-17(27)	Solids Evap. Concentrator (All Plants)	0.6
3-01-027-18(28)	Coating Operation	0.4
3-01-027-12	High Density Prilling (Solids Form.)	0.36
3-01-027-22	Low Density Prilling (Solids Form.)	0.18
3-01-027-07	Rotary Drum Granulators (Solids Form.)	0.04
3-01-027-08	Pan Granulators (Solids Form.)	0.01
3-01-027-14	High Density Prilling (Coolers/Dryers)	0.36
3-01-027-24	Low Density Prilling (Coolers/Dryers)	0.18
3-01-027-25	Low Density Prilling/Drying (Coolers/Dryers)	0.18
3-01-027-29	Rotary Drum Granulators (Coolers/Dryers)	0.032
3-01-027-30	Pan Granulator Coolers (Coolers/Dryers)	0.006

Table 3.17-2. Urea Emission Factor SCCs and Weighting Factors

SCC	Description	Weighting Factor
3-01-040-02	Solution Concentration	1.0
3-01-040-04	Drum Granulation	0.45
3-01-040-08	Nonfluid Bed Prilling (Agricultural Grade)	0.07
3-01-040-09	Nonfluid Bed Prilling (Feed Grade)	0.005
3-01-040-10	Fluid Bed Prilling (Agricultural Grade)	0.07
3-01-040-11	Fluid Bed Prilling (Feed Grade)	0.005
3-01-040-12	Rotary Drum Cooler	0.045
3-01-040-06	Bagging	0.045

3.18   CHEMICAL AND ALLIED PRODUCT MANUFACTURING - PAINT, VARNISH, LACQUER, AND ENAMEL MANUFACTURING: 04-05

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source category.

Tier I Category   Tier II Category

(04) CHEMICAL AND ALLIED   (05) Paint, Varnish, Lacquer,
        PRODUCT   Enamel Manufacturing
        MANUFACTURING

3.18.1   Technical Approach

The VOC emissions included in this Tier category were the emissions from the source category listed above. Emissions were estimated only for VOC from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, the activity indicator was expressed in thousand short tons and the emission factor was expressed in metric pounds/short ton. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984.

3.18.2   Activity Indicator

The activity indicator for paint manufacturing was the total shipments of paint and allied products obtained from Reference 1.

3.18.3   Emission Factor

The emission factor for paint manufacturing was the sum of the emission factors for general mixing/handling (SCC 3-01-014-01) and varnish manufacture, oleoresinous (SCC 3-01-015-02) obtained from Reference 2a.

3.18.4   Control Efficiency

The control efficiency for paint manufacturing was derived from Reference 3 or Reference 4 using Equation 3.18-1.

$$CE \quad = \quad \left[\frac{(UE - AE)}{UE} \right]$$

(Eq. 3.18-1)

where: CE = control efficiency
        UE = emissions before control
        AE = emissions after control

3.18.5   References

1. *Current Industrial Reports*, Paint and Allied Products. Bureau of the Census, U.S. Department of Commerce, Washington, DC. Annual.

2. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
    a.   Volume I, Table 5.10-1

3. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

4. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

3.19   CHEMICAL AND ALLIED PRODUCT MANUFACTURING - PHARMACEUTICAL MANUFACTURING: 04-06

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source category.

Tier I Category   Tier II Category

(04) CHEMICAL AND ALLIED   (06) Pharmaceutical
      PRODUCT   Manufacturing
      MANUFACTURING

3.19.1   Technical Approach

The VOC emissions included in this Tier category were the emissions from the source category listed above. Emissions were estimated only for VOC from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, the activity indicator was expressed in thousand short tons and the emission factor was expressed in metric pounds/short ton.

The procedures for determining activity indicators and emission factors were used for the years 1940, 1950, 1960, and 1970 through 1984.

3.19.2   Activity Indicator

The activity indicator for pharmaceutical manufacturing was the production index for drugs and medicines obtained from Reference 1. The index was multiplied by 10 to obtain the activity indicator for pharmaceuticals.

3.19.3   Emission Factor

The emission factor for pharmaceutical manufacturing was 63.1 lb VOC/ton and comes from Reference 2.

3.19.4   Control Efficiency

No control efficiencies were applied to the activity data to estimate VOC emissions from the manufacture of pharmaceuticals.

3.19.5   References

1.   *Chemical and Engineering News, Facts and Figures Issue*. American Chemical Society, Washington, DC. Annual.

2.   *Control Techniques for VOC Emissions from Stationary Sources*. EPA-450/3-85-008. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1985.

3.20   CHEMICAL AND ALLIED PRODUCTS MANUFACTURING - OTHER CHEMICAL MANUFACTURING: 04-07

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source categories.

Tier I Category	Tier II Category	Tier II Subcategory
(04) CHEMICAL AND ALLIED PRODUCT MANUFACTURING	(07) Other Chemical Manufacturing	Carbon Black Soap and Detergents

3.20.1   Technical Approach

The CO, PM-10, TSP, SO_2, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators was expressed in thousand short tons and emission factors were expressed in metric pounds/short ton. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to Equation 3.20-1.

$$PM\text{-}10\ Emissions_{year}\ =\ PM\text{-}10\ Emissions_{1975}\ \times\ \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}} \qquad \text{(Eq. 3.20-1)}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.20.2   Activity Indicator

3.20.2.1 CO Emissions

The activity indicators for carbon black production by the oil and gas processes were based on the total quantity of carbon black produced as reported in Reference 1. It was assumed that 90 percent of total production was by the oil process and 10 percent of total production was by the gas process. For

the years 1940 through 1973, the activity of carbon black production by the channel process was obtained from Reference 2. After 1973, production by this process was assumed to be zero.

3.20.2.2 PM-10 and TSP Emissions

The activity indicators for carbon black production by the oil and gas processes were based on the total quantity of carbon black produced obtained from Reference 1. It was assumed that 90 percent of total production was by the oil process and 10 percent of total production was by the gas process. For the years 1940 through 1973, the activity of carbon black production by the channel process was obtained from Reference 2. After 1973, production by the channel process was assumed to be zero.

The activity indicators for charcoal and soap and detergent production were based on the corresponding production figures obtained from Reference 3. Because this reference was only published every 5 years, the data from the year of publication prior to the year under study was projected to the year under study. The growth factor was based on the production index reported in Reference 1. It was calculated as the ratio between the production index for year under study and the production index for the publication year of Reference 3. The overall calculation is summarized in Equation 3.20-2.

$$Activity\ Indicator_i \ = \ Production\ figure_j \times \frac{Production\ index_i}{Production\ index_j} \qquad \text{(Eq. 3.20-2)}$$

where: i =   year under study
j =   year of preceding publication of Reference 2

3.20.2.3 SO$_2$ Emissions

The activity indicator for carbon black production was the total carbon black production obtained from Reference 1. This activity was not divided by process.

3.20.2.4 VOC Emissions

The activity indicators for carbon black production by the oil and gas processes were based on the total quantity of carbon black produced obtained from Reference 1. It was assumed that 90 percent of total production was by the oil process and 10 percent of total production was by the gas process. For the years 1940 through 1973, the activity of carbon black production by the channel process was obtained from Reference 2. After 1973, production by the channel process was assumed to be zero.

3.20.3   Emission Factor

3.20.3.1 CO Emissions

The emission factor for carbon black production by the oil process (SCC 3-01-005-04) was obtained from Reference 4a. The emission factors for carbon black production by the gas process (SCC 3-01-005-03) and the charcoal process were obtained from Reference 5.

3.20.3.2 PM-10 and TSP Emissions

The TSP emission factors for carbon black production by the oil process (SCC 3-01-005-04) was obtained from Reference 4a. The TSP emission factors for carbon black production by the gas process (SCC 3-01-005-03) and the channel process were obtained from Reference 4c. The PM-10 emission factors for the three carbon black production processes were obtained from Reference 6.

The emission factors for charcoal were derived from the emission factors for charcoal kiln (SCC 3-01-006-03) and charcoal briquetting (3-01-006-05) obtained from Reference 4b for TSP and from Reference 6 for PM-10. The overall charcoal emission factors were the sum of the kiln emission factor and a specific percentage of the briquetting emission factor. For the years 1980 through 1984, this was 90 percent. For each preceding year through the year 1950, the percentage was decreased by one. The percentage was held constant from 1940 to 1950.

The emission factors for soap and detergent production (SCC 3-01-009-01) were obtained from Reference 4c for TSP and from Reference 6 for PM-10.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier II category.

3.20.3.3 SO$_2$ Emissions

The emission factor for carbon black production was based on the emission factor for flared furnace exhaust, oil process obtained from Reference 4a and the CO control efficiency for carbon black production by the oil process. The description of this CO control efficiency is presented in the next section. The SO$_2$ emission factor was calculated according to Equation 3.20-3.

$$EF_{SO_2,\ carbon\ black} = (CE_{CO,\ carbon\ black} / 0.913) \times EF_{Flared\ Furnace\ Exhaust} \qquad \text{(Eq. 3.20-3)}$$

where: EF = emission factor
          CE = control efficiency, expressed as a fraction

3.20.3.4 VOC Emissions

The emission factor for carbon black production by the oil process (main vent, SCC 3-01-005-04) was obtained from Reference 4a. The emission factors for carbon black production by the gas process (main vent, SCC 3-01-005-03) and the channel process were obtained from Reference 5.

3.20.4   Control Efficiency

3.20.4.1 CO Emissions

The control efficiencies for carbon black production by both the oil process and gas process were computed from actual and uncontrolled emissions reported in Reference 7 or Reference 8 using Equation 3.20-4.

$$CE \;\; = \;\; \left[\frac{(UE - AE)}{UE} \right] \qquad \text{(Eq. 3.20-4)}$$

where: CE =   control efficiency
           UE =   emissions before control
           AE =   emissions after control

No control efficiencies were applied to the activity data for carbon black production by the channel process.

3.20.4.2 PM-10 and TSP Emissions

The TSP control efficiencies for carbon black production by the oil process and gas process and for soap and detergent production were derived from Reference 7 or Reference 8 using the same equation given above for the CO control efficiencies. No control efficiencies were applied to the activity data for carbon black production by the channel process.

The TSP control efficiency for charcoal production was calculated based on the control on kilns (SCC 301-006-01) for either CO, TSP, or VOC emissions obtained from Reference 7 or Reference 8. The TSP control efficiency for this process was calculated using Equation 3.20-5.

$$CE_{charcoal} \;\; = \;\; \frac{(EF_{kiln} \times CE_{kiln}) + (EF_{Briquetting} \times 0.9 \times 0.95)}{(EF_{kiln} + EF_{Briquetting} \times 0.9)} \qquad \text{(Eq. 3.20-5)}$$

where: CE =   control efficiency
           EF =   emission factor

The PM-10 control efficiencies for carbon black, charcoal, and soap and detergent production for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 9. During these years, any changes in the corresponding TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

3.20.4.3 SO$_2$ Emissions

No control efficiencies were applied to the activity data to estimate SO$_2$ emissions from the carbon black production processes.

3.20.4.4 VOC Emissions

The VOC control efficiencies for carbon black production processes were 85 percent of the CO control efficiencies for the corresponding production process.

3.20.5   References

1. *Chemical and Engineering News, Facts and Figures Issue*. American Chemical Society, Washington, DC. Annual.

2. *Minerals Yearbook*, Carbon Black. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.

3. *Census of Manufactures*. Bureau of the Census, U.S. Department of Commerce, Washington, DC. Available every five years.

4. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
    a.   Volume I, Table 5.3-3
    b.   Volume I, Table 5.4-1
    c.   Volume I, Table 5.15-1

5. *Compilation of Air Pollutant Emission Factors, Third Edition, Supplements 1 through 14, AP-42*. NTIS PB-275525. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1977.

6. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listings for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

7. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

8. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

9. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.

3.21   METALS PROCESSING - NONFERROUS: 05-01

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source categories.

Tier I Category	Tier II Category	Tier II Subcategory
(05) METALS PROCESSING	(01) Nonferrous	Primary Metals Industry (aluminum, copper, zinc, and lead) Secondary Metal Industry (aluminum, lead, and copper) Nonferrous Smelters (copper, zinc, and lead)

3.21.1   Technical Approach

The CO, PM-10, TSP, and SO_2 emissions included in this Tier category were the sum of the emissions from the source categories listed above. No estimates were made for VOC. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in thousand short tons and emission factors were expressed in metric pounds/short ton. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to Equation 3.21-1.

$$PM\text{-}10 \ Emissions_{year} \ = \ PM\text{-}10 \ Emissions_{1975} \ \times \ \frac{TSP \ Emissions_{year}}{TSP \ Emissions_{1975}} \qquad \text{(Eq. 3.21-1)}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.21.2　Activity Indicator

3.21.2.1　CO Emissions

Primary aluminum production was obtained from Reference 1. This production level was used as the activity indicator for primary aluminum.

3.21.2.2　PM-10 and TSP Emissions

3.21.2.2.1　*Primary Metals Industry - Aluminum —*
The production of calcined alumina, obtained from Reference 2a, was the activity indicator for calcining of hydroxide. The primary aluminum production, obtained from Reference 1, was the activity indicator for material handling.

The Horizontal Stud Soderberg (HSS) stack was assigned an activity equivalent to 18.5 percent of the total primary aluminum production. Activity of the HSS fugitive was assumed to equal to that for HSS stack. The Vertical Stud Soderberg (VSS) stacks was assigned an activity equivalent to 10.5 percent of the total primary aluminum production. The activity of VSS fugitives was assumed to equal to that of VSS stacks.

Stack and fugitive prebake were each assigned an activity equivalent to 71 percent of the total primary aluminum production. The activity of anode baking was assumed to equal to that of prebake.

3.21.2.2.2　*Primary Metals Industry - Copper —*
The activity indicator for roasting was based on the primary copper smelter production from domestic and foreign ores from Reference 3a. This reference provided the units of blister copper produced. It was assumed that of the 4 tons of copper concentrate/ton of blister, only half was roasted. Therefore, units of blister copper produced multiplied by 2 resulted in the activity indicator for roasting.

The activity indicators for smelting and converting were assumed to be equivalent. The activities were calculated in the same manner as for roasting, except it was assumed that all of the blister copper produced is smelted and converted. Therefore, units of blister copper produced multiplied by 4 resulted in the activity indicators for smelting and converting.

The total new copper smelter production figure obtained from Reference 3b was used as the activity indicator for fugitives.

3.21.2.2.3　*Primary Metals Industry - Zinc —*
The activity indicator for roasting was assigned the total slab zinc production obtained from the Reference 4. The production figure was converted to short tons and multiplied by 2 to account for the fact that there are 2 units of concentrate/ton slab zinc.

The activity indicator for sintering was assigned the redistilled slab zinc production obtained from Reference 4a. The activity indicator for electrolytic processes was estimated by subtracting the redistilled slab zinc production from total slab zinc production. These data were obtained from Reference 4.

The activity indicator for horizontal retort process was assume to be zero. The activity indicator for vertical retort processes was assigned the same value as used for zinc sintering.

Total slab zinc production figure obtained from Reference 4 was used as the activity for fugitive processes.

3.21.2.2.4   *Primary Metals Industry - Lead —*
The activities for the sintering process, blast furnaces, reverberatory furnaces, and fugitive processes were set equal to the primary refined lead production from domestic and foreign ores obtained from Reference 5.

3.21.2.2.5   *Secondary Metals - Aluminum —*
The activity indicator for sweating was the total consumption of all scrap by "sweated pig" and "borings and turnings" was obtained from Reference 1. Total of all scrap consumed, also from Reference 1, was the activity indicator for refining.

The activity indicator for fluxing was based on the quantities of magnesium recovered from new and old aluminum-based scrap obtained from Reference 6a. The quantities of magnesium were summed and multiplied by 4.

The activity indicator for fugitive processes was the total quantity of secondary aluminum recovered obtained from Reference 1.

3.21.2.2.6   *Secondary Metals - Lead —*
The data used to estimate the activity for the four lead processes were obtained from Reference 5. The pot furnace activity was estimated as 90 percent of the total consumption of lead scrap by all consumers obtained from Reference 5a. The activity indicator for reverberatory furnaces was calculated by multiplying the total consumption of lead scrap by the ratio between the quantity of lead recovered as soft lead and the total lead recovered from scrap. The activity indicator for blast furnaces was calculated by multiplying the total consumption of lead scrap by the ratio between lead recovered as antimonial lead and the total lead recovered from scrap. The total quantity of secondary lead recovered in the U.S. was used as the activity indicator for fugitive processes.

3.21.2.2.7   *Secondary Metals - Copper —*
The data used to estimate the activity for the four copper processes were obtained from Reference 3. The activity for wire burning was calculated as one-half of the total consumption of No. 2 wire obtained from Reference 3c. The activity for brass and bronze coating was calculated by multiplying the total consumption of scrap by the ratio between the copper recovered in alloys and the total secondary copper production. The activity for smelting was calculated by multiplying the total consumption of scrap by the ratio between the copper recovered as unalloyed copper and the total secondary copper production. The total quantity of copper recovered from all scrap was assigned the activity for fugitive processes.

3.21.2.3 *SO$_2$ Emissions*

The activity indicator for copper roasting was based on the primary copper smelter production from domestic and foreign ores from Reference 3a. This reference provided the units of blister copper

produced. It was assumed that of the 4 tons of copper concentrate/ton of blister, only half were roasted. Therefore, units of blister copper produced multiplied by 2 resulted in the activity indicator for copper concentrate roasting.

The activity indicators for copper smelting and converting were assumed to be equivalent. The activities were calculated in the same manner as for the roasting category, except it was assumed that all of the blister copper produced was smelted and converted. Therefore, units of blister copper produced multiplied by 4 resulted in the activity indicators for copper smelting and converting.

The activity indicator for zinc ore roasting was assigned the total slab zinc production obtained from the Reference 4. The production figure was converted to short tons and multiplied by 2 to account for the fact that there are 2 units of concentrate/ton slab zinc.

The determination for the activity indicator for lead processing required the following steps: (1) calculation of the quantity of SO_2 removed as by-product sulfuric acid by lead plants, (2) calculation of total SO_2 emissions from lead processing, and (3) calculation of lead processing activity indicator. Each of these steps are described below.

For the first step, the quantity of by-product sulfuric acid produced from lead plants was obtained from Reference 3. This value was multiplied by the ratio of the molecular weight of SO_2 to the molecular weight of sulfuric acid (64/98), in order to obtain the amount of SO_2 removed as sulfuric acid.

The second step required the actual quantity of SO_2 emitted from lead production (SCC 3-03-010-xx) obtained from Reference 7 or 8. The amount of SO_2 removed as sulfuric acid was added to the actual amount of SO_2 emitted to calculate the total amount of SO_2 emitted by lead processing.

$$Emissions_{SO_2, \ lead \ proc.} \ = \ H_2SO_{4_{SO_2,lead \ proc.}} \ + \ Emissions_{SO_2,actual} \qquad \text{(Eq. 3.21-2)}$$

The last step in this method calculated the production level for lead processing by using the total amount of SO_2 emitted by lead processing, converted to metric pounds, and the emission factor for lead processing. The emission factor was determined according to the description presented later in this section. Equation 3.21-3 was used to complete the calculation of the activity indicator for lead processing.

$$Production_{lead \ proc.} \ = \ \frac{Emission_{SO_2,lead \ proc.} \ \times \ 2000 \, lb/ton}{540 \, lb \ SO_2/tons \ lead \ proc.} \qquad \text{(Eq. 3.21-3)}$$

The primary aluminum production obtained from Reference 1 was the activity indicator for primary aluminum processes.

The data used to estimate the activity for the two furnace types used in secondary lead production were obtained from Reference 5. The activity indicator for reverberatory furnaces was calculated by multiplying the total consumption of lead scrap by the ratio between the quantity of lead recovered as soft

lead and the total lead recovered from scrap. The activity indicator for blast furnaces was calculated by multiplying the total consumption of lead scrap by the ratio between lead recovered as antimonial lead and the total lead recovered from scrap.

3.21.3   Emission Factor

3.21.3.1 CO Emissions

The emission factor for primary aluminum was obtained from Reference 9.

3.21.3.2 PM-10 and TSP Emissions

3.21.3.2.1   *Primary Metals Industry - Aluminum* —
The TSP emission factors for all aluminum production processes, with the exception of material handling, were obtained from Reference 10a. The TSP emission factor for material handling was obtained from Reference 11a. The PM-10 emission factors for all aluminum production processes were obtained from Reference 12. The SCCs corresponding to each of the production processes are presented in Table 3.21-1.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from these emission sources.

3.21.3.2.2   *Primary Metals Industry - Copper* —
The emission factors for roasting were the weighted averages of the emission factors for two process types listed in Table 3.21-2. The TSP emission factor was obtained from Reference 10b and the PM-10 emission factors were obtained from Reference 12. Weighting factors were the 1981 capacity for each process type as presented in Table 3.21-2.

The emission factors for smelting were the weighted averages of the emission factors for four process types. The emission factors were obtained from Reference 10b for TSP and from Reference 12 for PM-10. These emission factors were weighted using the 1981 capacity for each process. The SCCs and descriptions of the four processes along with the 1981 capacity data are presented in Table 3.21-3.

The emission factors for converting were obtained from Reference 10c for TSP and from Reference 12 for PM-10. The TSP emission factor for fugitive processes was obtained from Reference 13. The PM-10 emission factor for fugitive processes was obtained from Reference 12 or Table 3.1-3 of this report.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from these emission sources.

3.21.3.2.3   *Primary Metals Industry - Zinc* —
The emission factors were obtained from Reference 10c for the following processes: roasters (SCC 3-03-030-02 for multiple hearth roaster), sintering (SCC 3-03-030-03), electrolytic (SCC 3-03-030-06), and vertical retorts (SCC 3-03-030-05). The emission factor for horizontal retorts (SCC 3-03-030-xx) was obtained from Reference 11b. The PM-10 emission factors for these processes were obtained from

Reference 12. The emission factors for fugitive processes were obtained from Reference 13 for TSP and from Reference 12 or Table 3.1-3 of this report for PM-10.

The emission factors for sintering, electrolytic, horizontal retorts, vertical retorts, and fugitive processes were multiplied by 2 to account for the fact that there were 2 units of concentrate/ton of slab zinc.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from these emission sources.

3.21.3.2.4   *Primary Metals Industry - Lead —*
The emission factors were obtained from Reference 10d for the following processes: sintering (SCC 3-03-010-01), blast furnaces (SCC 3-03-010-02), and reverberatory furnaces, dross (SCC 3-03-010-03). The PM-10 emission factors for these processes were obtained from Reference 12. The emission factors for fugitive processes were obtained from Reference 13 for TSP and from Reference 12 or Table 3.1-3 of this report for PM-10.

 The emission factors for sintering and blast furnaces were multiplied by 2 to account for the fact that there were 2 units of concentrate/ton of slab lead.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from these emission sources.

3.21.3.2.5   *Secondary Metal Industry - Aluminum —*
The emission factors for sweating were the weighted averages of the emission factors for sweating furnaces (SCC 3-04-001-01) and scrap dryers (3-04-002-07). The TSP emission factors for these processes were obtained from Reference 10e and 10f; the PM-10 emission factors were obtained from Reference 12. The scrap dryer emission factors were used as surrogates. The sweating furnace emission factors were weighted by the consumption of sweated pig and the scrap dryer emission factors were weighted by the consumption of borings and turnings. Consumption data were obtained from Reference 1.

The emission factors for refining were the weighted averages of the emission factors for smelting furnace/crucible (SCC 3-04-001-02) and smelting furnace/reverberatory (3-04-001-03). The TSP emission factors were obtained from Reference 10e and the PM-10 emission factors from Reference 12. These emission factors were weighted based on Reference 7 or Reference 8.

The emission factors for fluxing (SCC 3-04-001-04) were obtained from Reference 10e for TSP and from Reference 12 for PM-10. The TSP emission factor for fugitive processes was obtained from Reference 13. The PM-10 emission factor for fugitive processes was obtained from Reference 12 or Table 3.1-3 of this report.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from these emission sources.

3.21.3.2.6   Secondary Metal Industry - Lead —

The emission factor for pot furnaces or kettle refining (SCC 3-04-004-01), reverberatory furnaces (SCC 3-04-004-02), and blast furnaces (SCC 3-04-004-03) was obtained from Reference 11c The PM-10 emission factors for these processes were obtained from Reference 12. The fugitive processes emission factors were obtained from Reference 13. The PM-10 emission factor for fugitive processes was obtained from Reference 12 or Table 3.1-2 of this report.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from these emission sources.

3.21.3.2.7   Secondary Metal Industry - Copper —

The emission factors for wiring burning were obtained from Reference 14 for TSP and from Reference 12 for PM-10.

The emission factors for brass and bronze casting were the weighted averages of the emission factors for five casting methods added to the emission factor for a sixth method, cupola (SCC 3-04-002-12). All TSP emission factors were obtained from Reference 10f. The PM-10 emission factors were obtained from Reference 12. Operating rates obtained from Reference 9 for the five casting methods were used to calculated the weighted average emission factors. The casting methods, SCCs, and weighting factors for the five casting methods are presented in Table 3.21-4. The resulting weighted average emission factors were added to the cupola emission factors to obtain the overall brass and bronze casting PM-10 and TSP emission factors.

The emission factor for smelting were the weighted sum of the emission factors for the following four smelter types: (1) cupola, scrap copper (SCC 3-04-002-10), (2) reverberatory, scrap copper (SCC 3-04-002-14), (3) electric arc, scrap copper (SCC 3-04-002-20), and electric induction, scrap copper (SCC 3-04-002-23). These emission factors were obtained from Reference 10f for TSP and from Reference 12 for PM-10. The emission factors were summed according to Equation 3.21-4.

$$EF \; = \; EF_C \; + \; (2 \times EF_{RF}) \; + \; [(EF_{EA} \; + \; EF_{EI}) \; / \; 2] \qquad \text{(Eq. 3.21-4)}$$

where: EF = emission factor
   C = cupola for scrap copper
   RF = reverberatory furnace for scrap copper
   EA = electric arc for scrap copper
   EI = electric induction

The TSP emission factor for fugitive processes was obtained from Reference 11d. The PM-10 emission factor was obtained from Reference 12 or Table 3.1-3 of this report.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from these emission sources.

3.21.3.3 SO₂ Emissions

The emission factor for roasting was the weighted average of the emission factors for two process types. The emission factors were obtained from Reference 10b and were weighted using the 1981 capacity for each process type. The SCCs and descriptions of the two process types along with the 1981 capacity data are presented in Table 3.21-2. To account for fugitive emissions, 1 lb/ton was added to the weighted average emission factor.

The emission factor for copper smelting was the weighted average of the emission factors for six process types. Emission factors were obtained from Reference 10b and were weighted using the 1981 capacity for each process type. The SCCs and descriptions of the six process types along with the 1981 capacity data are presented in Table 3.21-5. The weighting factors were changed from the 1981 capacity data when an existing smelter ceased operations, a new smelter began operations, or an existing smelter was modified. This information was obtained from Reference 3a. To account for fugitive emissions, 4 lb/ton was added to the weighted average emission factor.

The emission factor for copper converting was the weighted average of the emission factors for six process types. The emission factors were obtained from Reference 10b, except for the noranda reactor emission factor which was assumed. The emission factors were weighted using the 1981 capacity for each process type. The SCCs and descriptions of the six process types along with the 1981 capacity data are presented in Table 3.21-6. To account for fugitive emissions, 130 lb/ton was added to the weighted average emission factor.

The emission factor for zinc roasting (SCC 3-03-030-02) was obtained from Reference 10d.

The emission factor for lead roasting was the sum of the emission factors for sintering (SCC 3-03-010-01) and blast furnace (SCC 3-03-010-02). These emission factors were obtained from Reference 10d.

The emission factor for primary aluminum was obtained from Reference 9.

The emission factors for secondary lead processing in reverberatory furnaces (SCCS-04-004-02) and blast furnaces (SCC 3-04-004-03) were obtained from Reference 10g.

3.21.4 Control Efficiency

3.21.4.1 CO Emissions

No control efficiencies were applied to the activity data to estimate emissions from primary aluminum production.

3.21.4.2 PM-10 and TSP Emissions

The TSP control efficiencies for all primary metals industry production processes and all secondary metals industry production processes, except for any fugitive processes were derived from Reference 7 or Reference 8 using Equation 3.21-5. For those processes where the emission factor was calculated as the

---

weighted average of the emission factors of several process types, the control efficiency was calculated as the weighted average of the individual control efficiencies in the same manner.

$$CE = \left[\frac{(UE - AE)}{UE} \right]$$ (Eq. 3.21-5)

where: CE = control efficiency
UE = emissions before control
AE = emissions after control

The TSP control efficiencies for the primary metals industry fugitive processes for aluminum, copper, lead and zinc production were obtained by engineering judgment. No additional information is currently available concerning the origin of these TSP control efficiencies. The same is true for the control efficiencies for the secondary metals industry fugitive processes for aluminum, lead, and copper.

The PM-10 control efficiencies for all primary metals industry and secondary metals industry production process, excluding the fugitive processes for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 15. During these years, any changes in the corresponding TSP control efficiencies from the 1985 TSP control efficiency values were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

No control efficiencies were applied to the activity data to estimate PM-10 emissions from fugitive processes for either the primary metals industry or the secondary metals industry.

3.21.4.3 SO$_2$ Emissions

No control efficiencies were applied to the activity data to estimate SO$_2$ emissions from the source included in this Tier II category.

3.21.5   References

1. *Minerals Yearbook*, Aluminum. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.

2. *Minerals Yearbook*, Bauxite and Alumina. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.
    a.   Table entitled, "Production and Shipments of Alumina in the U.S."

3. *Minerals Yearbook*, Copper. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.
    (a) Table entitled, "Copper: World Smelter Production, by country."
    (b) Table entitled, "Primary and Secondary Copper Produced by Refineries and Electrowinning plants in the U.S."

(c)   Table entitled, "Consumption of Copper-base Scrap in the U.S. in 19xx."

4.   *Minerals Yearbook*, Zinc. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.
     (a)   Table entitled, "Production of Zinc Products from Zinc-based Scrap in the U.S.: Redistilled Slab Zinc."

5.   *Minerals Yearbook*, Lead. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.
     (a)   Table entitled, "Stocks and Consumption of new and old Lead Scrap in the U.S."
     (b)   Table entitled, "U.S. Consumption of Lead, by Product".

6.   *Minerals Yearbook*, Magnesium. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.
     (a)   Table entitled, "Magnesium Recovered from the Scrap Processed in the U.S. by Kind of Scrap and Form of Recovery"

7.   *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

8.   *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

9.   *Computer Retrieval, NE257 report, by Source Classification Code (SCC) from the National Emission Data System (NEDS)*. Unpublished computer report. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. February 9, 1980.

10. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
     a.   Volume I, Table 7.1-2
     b.   Volume I, Table 7.3-2
     c.   Volume I, Table 7.7-1
     d.   Volume I, Table 7.6-1
     e.   Volume I, Table 7.8-1
     f.   Volume I, Table 7.9-1
     g.   Volume I, 7.11-1

11. *Compilation of Air Pollutant Emission Factors, Third Edition, Supplements 1 through 14, AP-42*. NTIS PB-275525. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1977.
     a.   Volume I, Part B, Table 7.1-2
     b.   Volume I, Part B, Table 7.7-1

  c. Volume I, Table 7.11-1

  d. Volume I, Table 7.9-2

12. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listings for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

13. *Assessment of Fugitive Particulate Emission Factors for Industrial Processes*. EPA-450/3-78-107. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1978.

14. Internal Memorandum, "OAQPS Data File Emission Estimate from Copper Wire Burning." From Robert Rosenteel, Standards Support Section, to Chuck Mann, U.S. Environmental Protection Agency, Research Triangle Park, NC. November 16, 1979.

15. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.

Table 3.21-1. PM-10 Emission Factors SCCs for the Primary Metals Industry - Aluminum

SCC	Description
3-03-002-01	Calcining of Hydroxide
3-03-001-02	HSS - Stack
3-03-001-09	HSS - Fugitive
3-03-001-03	VSS - Stack
3-03-001-10	VSS - Fugitive
3-03-001-01	Prebake - Stack
3-03-001-08	Prebake - Fugitive
3-03-001-05	Anode Baking
3-03-001-04	Materials Handling

Table 3.21-2. PM-10 and SO$_2$ Emission Factors SCCs and Weighting Factors for the Primary Metals Industry - Copper Roaster

SCC	Description	1981 Capacity
3-03-005-02	Multiple Hearth Roaster	430
3-03-005-09	Fluidized Bed Roaster	230

Table 3.21-3. PM-10 Emission Factors SCCs and Weighting Factors for the Primary Metals Industry - Copper Smelting

SCC	Description	1981 Capacity
3-03-005-07	Reverb. Furnace w/o Roasting	636
3-03-005-31	Reverb. Furnace + Multi-Hearth Reverb.	430
3-03-005-32	Furnace + Fluid Bed Roaster	212
3-03-005-10	Electric Smelting Furnace	257

Table 3.21-4. PM-10 Emission Factors SCCs and Weighting Factors for the Secondary Metals Industry - Copper Brass and Bronze Casting

SCC	Description	Weighting Factors
3-04-002-15	Reverberatory - Brass & Bronze	36
3-04-002-17	Rotary - Brass & Bronze	300
3-04-002-19	Crucible & Pot - Brass & Bronze	21
3-04-002-21	Electric Arc - Brass & Bronze	11
3-04-002-24	Electric Induction - Brass & Bronze	20

Table 3.21-5. SO$_2$ Emission Factors SCCs and Weighting Factors for the Primary Metals Industry - Copper Smelting

SCC	Description	1981 Capacity
3-03-005-03	Multi-Hearth + Reverb. Furnace + Convertors	405
3-03-005-07	Reverb. Furnace + Convertors	430
3-03-005-10	Electric Furnace + Convertors	212
3-03-005-25	Fluid Bed Roaster + Reverb. Furn. + Convertors	124
3-03-005-26	Flash Furnace + Cleaning Furnace + Convertor	18
3-03-005-	Fluid Bed + Electric Arc + Convertors	115

Table 3.21-6. SO$_2$ Emission Factors SCCs and Weighting Factors for the Primary Metals Industry - Copper Converting

SCC	Description	Weighting Factor
3-03-005-23	Reverberatory Furnace + Convertor	405
3-03-005-24	Multi-Hearth + Reverb. + Convertor	448
3-03-005-25	Fluid Bed Roaster + Reverb. + Convertor	212
3-03-005-26	Electric Arc + Convertor	124
3-03-005-27	Flash Furn. + Cleaning Furn. + Convertor	115
3-03-005-28	Noranda Reactor + Convertor	231

3.22   METALS PROCESSING - FERROUS: 05-02

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source categories.

Tier I Category	Tier II Category	Tier II Subcategory
(05) METALS PROCESSING	(02) Ferrous	Iron and Steel Manufacturing Primary Metals Industry - ferroalloys Secondary Metals Industry - grey iron and steel foundries

3.22.1   Technical Approach

The CO, NO_x, PM-10, TSP, SO_2, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators for all processes, except for iron and steel industry processes were expressed in thousand short tons and emission factors were expressed in metric pounds/short ton. For iron and steel industrial processes emitting PM-10 and TSP, the activity indicators were expressed in million short tons and the emission factors were expressed in metric pounds/short ton. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to Equation 3.22-1.

$$PM\text{-}10\ Emissions_{year}\ =\ PM\text{-}10\ Emissions_{1975}\ \times\ \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}} \qquad \text{(Eq. 3.22-1)}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.22.2   Activity Indicator

3.22.2.1 CO Emissions

The activity indicator for cupola furnaces in iron foundries was based on the combined quantity of scrap and pig iron consumed by cupola furnaces. This value was obtained from Reference 1a under the category of iron foundries and miscellaneous users. The final activity was determined by adjusting this production value to account for the fact that the emission factor used for this subcategory was in terms of the charged quantity and not the fresh feed quantity. This adjustment required dividing the production value by 0.78 to account for recycling.

The activity indicator for by-product coke from steel manufacturing was the oven production figure, expressed in thousand short tons, from Reference 2a.

The activity indicator for steel manufacturing blast furnaces was the total pig iron production including exports obtained from Reference 2b.

The activity indicator for steel manufacturing sintering was one-third of the total production of pig iron obtained from Reference 2 or Reference 3.

The activity indicators for steel manufacturing open hearth and electric arc furnace types were based on the total scrap and pig iron consumption. Reference 1 contained the total scrap and pig iron consumed by each of three furnace types (including basic oxygen) by manufacturers of pig iron and raw steel and castings. The fraction of combined quantity of scrap and pig iron consumed by each of the three furnace types was calculated. The total raw steel production reported in Reference 2b was multiplied by the fractions for the open hearth and electric arc furnaces to obtain the raw steel production for these two furnace types.

3.22.2.2 NO$_x$ Emissions

The activity indicator for open hearth furnaces used in iron and steel manufacturing was based on the total scrap and pig iron consumption. Reference 1 contained the total scrap and pig iron consumed by each of the three furnace types (open hearth, basic oxygen, and electric arc) by manufacturers of pig iron and raw steel and castings. The fraction of the combined quantity of scrap and pig iron consumed by each of the three furnace types was calculated. The total raw steel production reported in Reference 2b was multiplied by the open hearth fraction to obtain the raw steel production for this furnace type.

The activity indicator for roll and finish processes in iron and steel manufacturing was the total raw steel production obtained from Reference 2a.

3.22.2.3 PM-10 and TSP Emissions

3.22.2.3.1   Iron and Steel Industry —
The activity indicator for by-product coke was the oven or by-product production figure from Reference 2a. The same activity indicator was used for coal preparation and coke handling.

The activity indicator for blast furnaces was the total pig iron production obtained from Reference 2b. This value included exports.

The activity indicators for windbox, discharge, and sinter-fugitive processes were based on the total production of pig iron obtained from Reference 2 or Reference 3. The activity indicator for each process was one-third of this production value.

The activity indicators for open hearth, basic oxygen, and electric arc furnaces were based on the total scrap and pig iron consumption. Reference 1 contained the total scrap and pig iron consumed by each furnace type by manufacturers of pig iron and raw steel and castings. The fraction of the combined quantity of scrap and pig iron consumed by each furnace type was calculated. The total raw steel production reported in Reference 2b was multiplied by each fraction to obtain the raw steel production for each furnace type. These final results were used as the activity indicators for the both "stack" and "fugitive" subcategories of each furnace type.

The activity indicator for slag blast furnaces was the total quantity of iron blast furnace slag sold reported in Reference 4. The same reference was used to obtain the total quantity of steel slag sold. This value was used as the activity indicator for slag steel furnaces.

The activity indicator for scarfing was one-third of the total raw steel production obtained from Reference 2b.

The activity indicators for teeming, soaking pits, reheat furnaces, and open dust were the total raw steel production reported in Reference 2b.

The activity indicator for ore screening was the total consumption of iron ore and agglomerates obtained from Reference 3.

3.22.2.3.2 *Primary Metals Industry (ferroalloys) —*
The activity indicator for ferrosilicon was the net gross weight production obtained from Reference 5a. The silicon manganese activity indicator was assumed to be 42.1 percent of the net production of ferrosilicon. The activity indicator for the ferromanganese, electric furnaces was assumed to be 57.9 percent of the net production of ferrosilicon. For the ferromanganese, blast furnace, the activity indicator was assumed to be zero.

The activity indicator for silicon metal was the production value obtained from Reference 6a. The activity indicator for other ferroalloys was the sum of the gross weight production figures for chromium alloys, ferrocolumbium, ferrophosphorus and other ferroalloys as reported in Reference 5a. For ferroalloy material handling, the total gross weight production of all ferroalloys obtained from Reference 5a was used as the activity indicator.

3.22.2.3.3 *Secondary Metals Industry —*
The activity indicator for cupola furnaces at grey iron foundries was based on the combined quantity of scrap and pig iron consumed by cupola furnaces. This value was obtained from Reference 1a under the category of iron foundries and miscellaneous users. The final activity was determined by adjusting this production value to account for the fact that the emission factor was in terms of the charged quantity

and not the fresh feed quantity. This adjustment required dividing the production value by 0.78 to account for recycling.

The activity indicator for electric induction furnaces at grey iron foundries was based on the combined quantity of iron and steel scrap and pig iron consumed in electric furnaces. This value was obtained from Reference 1a under the category of iron foundries and miscellaneous users. The final activity indicator was adjusted to account for recycling by dividing the consumption value by 0.78 to account for recycling.

The activity indicator for iron fugitive processes at grey iron foundries was the sum of the activity indicators for the cupola and electric induction furnaces.

The activity indicators for electric arc and steel-fugitive processes at steel foundries were both based on the combined quantity of iron and steel scrap and pig iron consumed. This value was obtained from Reference 1a under the category of manufacturers of steel casting. The final activity indicators used were the consumption value divided by 0.78 to account for recycling.

3.22.2.4 SO₂ Emissions

The activity indicator for coking in iron and steel manufacturing was the oven production figure obtained from Reference 2a.

The activity indicators for sintering in iron and steel manufacturing was based on the total production of pig iron obtained from Reference 2 or Reference 3.

The activity indicator for open hearth furnaces in iron and steel manufacturing was based on the total scrap and pig iron consumption. Reference 1 contained the total scrap and pig iron consumed by each furnace type (open hearth, basic oxygen, and electric arc) by manufacturers of pig iron and raw steel and castings. The fraction of the combined quantity of scrap and pig iron consumed by each of the three furnace types was calculated. Total raw steel production reported in Reference 2b was multiplied by the fraction for open hearth furnaces to obtain the raw steel production for this furnace type.

The activity indicator for roll and finish processes was the total raw steel production obtained from Reference 2b.

3.22.2.5 VOC Emissions

The activity indicator for by-product coke was the oven production figure obtained from Reference 2a. The activity indicator for sintering was based on the total production of pig iron obtained from Reference 2 or Reference 3.

3.22.3   Emission Factor

3.22.3.1 CO Emissions

The emission factor for iron foundries (SCC 3-04-003-01) was obtained from Reference 7a.

The emission factor for by-product coke from steel manufacturing was the sum of the emission factors for three separate processes: charging (SCC 3-03-003-02), pushing (SCC 3-03-003-03) and oven/door leaks (SCC 3-03-003-08). These emission factors were obtained from Reference 7b. The units of the emission factor were changed from quantity of coal charged to quantity of coke produced by using the relationship that one ton of coal charged produces 0.7 tons of coke.

The emission factors for steel manufacturing windbox sintering (SCC 3-03-008-13), basic oxygen furnaces (SCC 3-03-009-13 and 3-03-009-14), and electric arc furnaces (SCC 3-03-009-04 and 3-03-009-08) were obtained from Reference 7c.

The uncontrolled emission factor for steel manufacturing blast furnaces was obtained from Reference 8a. The control emission factor was calculated by applying the control efficiency as shown in Equation 3.22-2.

$$EF_{controlled} \ = \ EF_{uncontrolled} \ \times \ (1 \ - \ CE) \qquad\qquad \text{(Eq. 3.22-2)}$$

where: EF = emission factor
        CE = control efficiency

For the years 1970 through 1984, the control efficiency for blast furnaces was assumed to the 0.999. The control efficiencies for the years 1960, 1950, and 1940 were 0.995, 0.990, and 0.975, respectively.

3.22.3.2 NO$_x$ Emissions

3.22.3.2.1   Iron and Steel Industry —
The emission factor for open hearths was calculated by dividing the emissions by the operating rate as reported in Reference 9.

The emission factor for roll and finish was based on the emissions from the fuels used in this process divided by the process operating rate. The fuels used in this process were coke oven gas, residual oil, and natural gas. The emissions from roll and finish processes were assumed to be the difference between the total NO$_x$ emissions from iron and steel processes and the NO$_x$ emissions from open hearth furnaces.

The total NO$_x$ emissions from all iron and steel processes using coke oven gas, residual oil, and natural gas were the sum of the separate emissions from the three fuels. Emissions were calculated by multiplying the quantity of fuel consumed by the fuel specific emission factor. The quantity of coke oven gas consumed by iron and steel processes was assumed to be 40 percent of the total annual coke oven gas production as reported in Reference 10. The quantity of residual oil consumed was calculated by

multiplying the quantity of raw steel production obtained from Reference 2b by a factor converting tons of steel produced to the gallons of residual oil consumed (0.00738×10^6 gal/10^3 ton steel). The quantity of natural gas consumed was calculated in the same manner as was the quantity of residual oil consumed, except that a conversion factor of 4.25×10^6 cu. ft gas consumed/10^3 ton steel was used.

The NO_x emission factor for the combustion of coke oven gas was obtained from Reference 7. The emission factors for the combustion of residual oil, and natural gas were obtained from Reference 7h (industrial boilers) and 7i (small industrial boilers), respectively. Based on these emission factors and the fuel consumption data, the NO_x emissions from the combustion of coke oven gas, residual oil, and natural gas were calculated.

The sum of these emissions was the total NO_x emissions from the iron and steel processes. The quantity of emissions from the open hearth furnaces was calculated by multiplying the activity indicator by the emission factor. The origin of these data were described earlier in this section. The difference between the total NO_x emissions and the open hearth furnace emissions was assumed to be the emissions from the roll and finish process. The emission factor for this process was calculated by dividing the emissions by the total steel produced obtained from Reference 11a.

3.22.3.3 PM-10 and TSP Emissions

3.22.3.3.1   Iron and Steel Industry —
The PM-10 and TSP emission factors for by-product coke were based on the sum of the emission factors for following six SCCs: 3-03-003-02, 3-03-003-03, 3-03-003-04, 3-03-003-06, 3-03-003-08, and 3-03-003-14. The TSP emission factors for these SCCs were obtained from Reference 7b, with the exception of SCC 3-03-003-04. The emission factor for this SCC was obtained from Reference 8b. The PM-10 emission factors of the six SCCs were obtained from Reference 12. The sum of these emission factors for PM-10 and TSP were divided by 0.7 to convert the emission factors from the amount of coal charged to the amount of coke produced.

The TSP emission factor for coal preparation and coke handling was obtained from Reference 7. The PM-10 emission factor was obtained from Reference 13. The TSP emission factors for the beehive process for the years 1940 through 1975 were obtained from Reference 7. The PM-10 emission factors for this process for all years and the TSP emission factor after 1975 were assumed to be zero.

The TSP emission factors for blast furnaces were the sum of the emission factors reported in Reference 14a for the SCCs 3-03-008-01 and 3-03-008-02. The PM-10 emission factors for these two SCCs were obtained from Reference 12.

The emission factors for windbox (SCC 3-03-0080-13) and discharge (SCC 3-03-008-14) were obtained from Reference 7d for TSP and from Reference 12 for PM-10. The windbox emission factors were after coarse particle removal. The emission factors for fugitive processes (SCC 3-03-008-19) were obtained from Reference 13 for TSP and from Reference 12 for PM-10.

The TSP emission factor for the open hearth furnaces, stack subcategory (SCC 3-03-009-01) was obtained from Reference 7d. The open hearth furnace, fugitive subcategory TSP emission factor was

obtained from Reference 14. The PM-10 emission factors for these sources were obtained from Reference 12.

The TSP emission factor for the basic oxygen furnaces, stack subcategory (SCC 3-03-009-13) was obtained from Reference 7d. The basic oxygen furnace, fugitive subcategory TSP emission factor was obtained from Reference 13. The PM-10 emission factors for these sources were obtained from Reference 12.

The emission factors for the electric arc furnaces, stack subcategory were based on the emission factors for carbon steel, stack (SCC 3-03-009-04) and alloy steel, stack (SCC 3-03-009-08) obtained from Reference 7d for TSP and from Reference 12 for PM-10. Weighted average PM-10 and TSP emission factors were calculated from these emission factors. Weighting factors were the relative production levels of carbon and alloy steel as reported in Reference 11a. For the electric arc furnace, fugitive subcategory, PM-10 and TSP emission factors were obtained from Reference 12 and Reference 13, respectively.

The PM-10 and TSP emission factors for slag blast furnaces and steel furnaces were obtained from Reference 12 and Reference 13, respectively.

The emission factors for scarfing (SCC 3-03-009-32) were obtained from Reference 7d for TSP and from Reference 12 for PM-10.

The PM-10 and TSP emission factors for teeming, soaking pits, reheat furnaces, open dust, and ore screening were obtained from Reference 12 and Reference 13, respectively.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from these emission sources.

3.22.3.3.2   *Primary Metals Industry (ferroalloys) —*
The emission factors for ferrosilicon were based on the emission factors for the following three electric smelting processes: 50 percent Fe Si (SCC 3-03-006-01), 75 percent Fe Si (SCC 3-03-006-02), and 90 percent Fe Si (SCC 3-03-006-03). The TSP emission factors for these processes were obtained from Reference 7e. The PM-10 emission factors were obtained from Reference 12. Weighed averages of these PM-10 and TSP emission factors were calculated using ferrosilicon production levels obtained from Reference 6 as weighting factors.

The PM-10 and TSP emission factors for silicon manganese (SCC 3-03-006-05), ferromanganese, electric furnaces (SCC 3-03-007-01), and silicon metal (SCC 3-03-006-04) subcategories were obtained from Reference 7e and Reference 12, respectively. The activity for ferromanganese, blast furnaces was assumed to be zero and, therefore, no emission factor was necessary. The emission factors for other ferroalloys and ferroalloy material handling were obtained from Table 3.1-3 of this report. The emission factors for other ferroalloys were based on engineering judgement and those for ferroalloy material handling were based on data from Reference 15.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from these emission sources.

3.22.3.3.3   Secondary Metals —

The PM-10 and TSP emission factors for cupola furnaces (SCC 3-04-003-01) and electric induction furnaces (SCC 3-04-003-03) at grey iron foundries were obtained from Reference 7f. The emission factors for fugitive processes were the sum of the emission factors for all processes reported emitting to the atmosphere in Reference 8c. It was assumed that the magnesium treatment applied to only 20 percent of the production. The PM-10 emission factor for fugitive processes was obtained from Reference 12 or Table 3.1-3 of this report.

The PM-10 and TSP emission factors for steel foundries electric arc furnaces (SCC 3-04-007-01) at steel foundries were obtained from Reference 7g. The TSP emission factor for fugitive processes was the sum of the emission factors for all processes, except for magnesium treatment, reported emitting to the atmosphere in Reference 8c. The PM-10 emission factor for fugitive processes was obtained from Reference 12 or Table 3.1-3 of this report.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from these emission sources.

3.22.3.4 SO_2 Emissions

The emission factor for coking in iron and steel manufacturing was based on the emission factors for six processes. Charging (SCC 3-03-003-02) and interfering (SCC 3-03-003-06) emission factors were obtained from Reference 7b. Emission factors for pushing (SCC 3-03-003-03), quenching (SCC 3-03-003-04), oven/door leaks (SCC 3-03-003-08) and topside leaks (SCC 3-03-003-14) were obtained from Reference 12. Emission factors from all six processes were summed and the result was multiplied by 0.7 to convert the factors from the amount of coal consumed to the amount of coke produced.

The emission factor for sintering in iron and steel manufacturing was calculated by dividing the emissions by the production rate as reported in Reference 9. This same procedure was used to calculate the open hearth emission factor.

The emission factor for roll and finish in iron and steel manufacturing was based on the emissions from the fuels used in this process divided by the process operating rate. The fuels used in this process were coke oven gas and residual oil. The emissions from the roll and finish process were assumed to be the difference between the total SO_2 emissions from iron and steel processes and the SO_2 emissions from open hearth furnaces.

Total SO_2 emissions from all iron and steel processes using coke oven gas and residual oil were the sum of the separate emissions from the two fuels. The emissions were calculated by multiplying the quantity of fuel consumed by the fuel specific emission factor. The quantity of coke oven gas consumed by the iron and steel processes was assumed to be 40 percent of the total annual coke oven gas production as reported in Reference 10. The quantity of residual oil consumed was calculated by multiplying the quantity of raw steel production obtained from Reference 2b by a factor converting tons of steel produced to the gallons of residual oil consumed (0.00738×10^6 gal/10^3 ton steel).

The SO_2 emission factor for the combustion of coke oven gas was obtained from Reference 7. The emission factor for the combustion of residual oil was obtained from Reference 7i and multiplied by the

sulfur content obtained yearly for No. 6 fuel oil from Reference 16. Based on these emission factors and the fuel consumption data, the SO_2 emissions from the combustion of coke oven gas and residual oil were calculated.

Summing of these emissions resulted in the total SO_2 emissions from the iron and steel processes. The quantity of emissions from the open hearth furnaces was calculated by multiplying the activity indicator by the emission factor. The origin of these data were described earlier in this section. The difference between total SO_2 emissions and open hearth furnace emissions was assumed to be the emissions from the roll and finish processes. The emission factor for this process was calculated by dividing the emissions by the quantity of raw steel produced obtained from Reference 9.

3.22.3.5 VOC Emissions

The emission factor for coking was based on the emission factors for six processes. Charging (SCC 3-03-003-02) and pushing (SCC 3-03-003-03), and oven/door leaks (SCC 3-03-003-08) emission factors were obtained from Reference 7b. Emission factors for quenching (SCC 3-03-003-04), interfering (SCC 3-03-003-06) and topside leaks (SCC 3-03-003-14) were obtained from Reference 17. The emission factors from all six processes were summed and the result was multiplied by 0.7 to convert the factors from the amount of coal consumed to the amount of coke produced.

The VOC emission factor for windbox sintering (SCC 3-03-008-13) was obtained from Reference 17.

3.22.4 Control Efficiency

The control efficiencies for several processes were derived from the actual and uncontrolled emissions reported in Reference 18 or Reference 19 using Equation 3.22-3.

$$CE = \left[\frac{(UE - AE)}{UE} \right] \qquad \text{(Eq. 3.22-3)}$$

where: CE = control efficiency
        UE = uncontrolled emissions
        AE = actual emissions

3.22.4.1 CO Emissions

The control efficiency for iron foundries was derived from Reference 18 or Reference 19 using Equation 3.22-3.

The control efficiency for steel manufacturing basic oxygen furnaces was computed from Reference 18 or Reference 19 using Equation 3.22-3. For blast furnaces, the percentage control efficiency was assumed to be 99.9 percent. This was taken into account in the calculation of the CO emission factor and, therefore, no separate control efficiency was used. For all other steel manufacturing processes, no control efficiencies were applied to the activity data to estimate the CO emissions.

3.22.4.2 NO$_x$ Emissions

No control efficiencies were applied to the activity data to estimate NO$_x$ emissions from the iron and steel manufacturing processes included in this Tier II category.

3.22.4.3 PM-10 and TSP Emissions

3.22.4.3.1 *Iron and Steel Industry* —
The TSP control efficiencies for by-product coke production were derived from Reference 18 or Reference 19 using Equation 3.22-3. The control efficiencies for the beehive process for the years 1940, 1950, 1960, and 1970 through 1975 and for coal preparation/coke handling processes for the years 1976 through 1984 were based on the estimated control efficiency reported in Reference 13. These TSP control efficiencies were adjusted according to engineering judgement.

The PM-10 control efficiencies for by-product coke production for the years 1975 through 1984 were based on the 1985 PM-10 control efficiency obtained from Reference 20. During these years, any changes in the TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate the PM-10 emissions from by-product coke production. No control efficiencies were applied to the activity data to estimate PM-10 emissions from the beehive process or the coal preparation/coke handling processes.

For blast furnaces, the TSP control efficiencies for the years 1973 through 1984 were assumed to 0.996. No procedure for determining the control efficiencies for the years 1940, 1950, 1960, and 1970 through 1972 is currently available. The PM-10 control efficiencies for the years 1975 through 1984 were equal to the 1985 PM-10 control efficiency obtained from Reference 20. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions from blast furnaces.

The TSP control efficiencies for the windbox and discharge processes were derived from Reference 18 or Reference 19 using Equation 3.22-3. The control efficiencies for sinter-fugitive processes were based on the estimated control efficiency reported in Reference 13. This control efficiency was adjusted annually based on engineering judgement. The PM-10 control efficiencies for these three processes for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 20. During these years, any changes in the corresponding TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

The TSP control efficiencies for the stack processes of open hearth, basic oxygen, and electric arc furnaces were derived from Reference 18 or Reference 19 using Equation 3.22-3. The control efficiencies for the fugitive processes of the basic oxygen and electric arc furnaces were based on the estimated control efficiencies reported in Reference 13. The control efficiency for the fugitive processes of the basic oxygen furnace was assumed to be zero for all years.

The PM-10 control efficiencies for the stack processes of these three furnace types for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 20. During these years, any changes in the corresponding TSP control efficiencies from the 1985 TSP control

efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions. No control efficiencies were applied to the activity data to estimate PM-10 emissions from the fugitive processes of all three furnace types.

The TSP control efficiencies for slag blast and slag steel furnaces were based on the estimated control efficiencies reported in Reference 13. The yearly variations in these control efficiencies are assumed to be the results of adjustments made based on engineering judgement.

The PM-10 control efficiencies for slag steel furnaces for the years 1975 through 1984 were based on the 1988 PM-10 control efficiency obtained from Reference 20. During these years, any changes in the TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were use to PM-10 emissions. No control efficiencies were applied to the activity to estimate PM-10 emissions from slag blast furnaces.

The TSP control efficiencies for scarfing were derived from Reference 18 or Reference 19 using Equation 3.22-3. The PM-10 control efficiencies for the years 1975 through 1984 were based on the 1988 PM-10 control efficiency obtained from Reference 20. During these years, any changes in the TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were use to estimate PM-10 emissions for scarfing.

No control efficiencies were applied to the activity data to estimate PM-10 and TSP emissions from teeming, soaking pits, and reheat furnaces.

The TSP control efficiencies for open dust and ore screening were based on the estimated control efficiencies reported in Reference 13. The yearly variations in these control efficiencies are assumed to be the results of adjustments made based on engineering judgement. No control efficiencies were applied to the activity data to estimate PM-10 emissions from open dust and ore screening.

3.22.4.3.2   *Primary Metals Industry (ferroalloys) —*
The TSP control efficiencies for all production processes, except other ferroalloy production and ferroalloy material handling processes were derived from Reference 18 or Reference 19 using Equation 3.22-3. The TSP control efficiencies for ferroalloy production and ferroalloy material handling processes were based on engineering judgment.

The PM-10 control efficiencies for ferrosilicon, silicon manganese, and silicon metal production and the ferromanganese electric furnace for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 20. During these years, any changes in the corresponding TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

No control efficiencies were applied to the activity data to estimate PM-10 emissions from ferromanganese blast furnace, other ferroalloy production, and ferroalloy material handling processes.

3.22.4.3.3   Secondary Metals Industry —

The TSP control efficiencies for all grey iron and steel foundry processes were derived from Reference 18 or Reference 19 using Equation 3.22-3.

The PM-10 control efficiencies for all grey iron and steel foundry processes, excluding the fugitive processes for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 20. During these years, any changes in the corresponding TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

No control efficiencies were applied to the activity data to estimate PM-10 emissions from the fugitive processes of grey iron and steel foundries.

3.22.4.4 SO_2 Emissions

No control efficiencies were applied to the activity data to estimate SO_2 emissions from the iron and steel manufacturing processes included in this Tier II category.

3.22.4.5 VOC Emissions

No control efficiencies were applied to the activity data to estimate VOC emissions from the by-product coke and sintering processes included in this Tier II category.

3.22.5   References

1. *Minerals Industry Surveys*, Iron and Steel Scrap. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Monthly.
    (a) Table on consumption of iron and steel scrap and pig iron in the United States by type of furnace or other use.

2. *Survey of Current Business*. Bureau of Economic Analysis, U.S. Department of Commerce, Washington, DC.
    (a) Table containing information on "Petroleum, Coal, and Products."
    (b) Table containing information on "Metals and Manufactures."

3. *Minerals Industry Surveys*, Iron Ores. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Monthly.

4. *Minerals Yearbook*, Slag Iron and Steel. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.

5. *Minerals Yearbook*, Ferroalloys. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.
    (a) Table entitled, "Table 2. Ferroalloys Produced and Shipped from Furnaces in the U.S."

6. *Minerals Yearbook*, Silicon. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.
    (a) "Table 1. Production, Shipments, and Stocks of ... and Silicon Metal in the U.S. in 19xx"

7. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
    a. Volume I, Table 7.10-3
    b. Volume I, Table 7.2-1
    c. Volume I, Table 7.5-3
    d. Volume I, Table 7.5-1
    e. Volume I, Table 7.4-3
    f. Volume I, Table 7.10-2
    g. Volume I, Table 7.13-1
    h. Volume I, Table 1.3-1
    i. Volume I, Table 1.4-1

8. *Compilation of Air Pollutant Emission Factors, Third Edition, Supplements 1 through 14, AP-42*. NTIS PB-275525. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1977.
    a. Volume I, Table 7.5-1, Supplement 11, October 1980
    b. Volume I, Table 7.2-1, Supplement 11, October 1980
    c. Volume I, Table 7.10-2, Supplement 11, October 1980

9. *Computer Retrieval, NE257 report, by Source Classification Code (SCC) from the National Emission Data System (NEDS)*. Unpublished computer report. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. February 9, 1980.

10. *Quarterly Coal Report: January - March*. DOE/EIA-0121(xx/1Q). Energy Information Administration, U.S. Department of Energy, Washington, DC. Quarterly.

11. *Minerals Yearbook*, Iron and Steel. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.
    (a) Table 1, Salient Iron and Steel Statistics.

12. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listing for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

13. Internal Memorandum from Walt Barber to David Hawkins on Final Fugitive Emission Factors derived by Joint EPA/AISI Study. U.S. Environmental Protection Agency. November 6, 1978.

14. *Compilation of Air Pollutant Emission Factors, Second Edition, Supplements 1 through 14, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC.
    a. Volume I, Part B, Table 7.5-1

15. *Summary of Particulate and Sulfur Oxide Emission Reductions Achieved National for Selected Industrial Source Categories*. EPA-340/1-76-0086. U.S. Environmental Protection Agency. Washington, DC. November 1976.

16. *Heating Oils*. U.S. Department of Energy. Obtainable from the National Institute for Petroleum and Energy Research, ITT Research Institute, P.O. Box 2128, Bartlesville, OK. Annual.

17. Criteria Pollutant Emission Factors for the 1985 NAPAP Emissions Inventory

18. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

19. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

20. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.

3.23   METALS PROCESSING - NOT ELSEWHERE CLASSIFIED: 05-03

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source categories.

Tier I Category	Tier II Category	Tier II Subcategory
(05) METALS PROCESSING	(03) Metals Processing not elsewhere classified (NEC)	Mining Operations (iron ore mining, taconite processing, bauxite crushing, copper ore crushing, zinc ore crushing, and lead ore crushing)

3.23.1   Technical Approach

The PM-10 and TSP emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated only for particulate matter from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in thousand short tons and emission factors were expressed in metric pounds/short ton. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1992 for TSP and for the years 1975 through 1984 for PM-10. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to Equation 3.23-1.

$$PM\text{-}10 \ Emissions_{year} \ = \ PM\text{-}10 \ Emissions_{1975} \ \times \ \frac{TSP \ Emissions_{year}}{TSP \ Emissions_{1975}} \qquad \text{(Eq. 3.23-1)}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.23.2   Activity Indicator

The activity indicator for iron ore mining was the total quantity of crude iron ore mined obtained from Reference 1. The activity indicator for taconite processing was the quantity of pellet production (agglomerates) obtained from Reference 1a. The activity indicator for bauxite crushing was the consumption of crude and dried bauxite (domestic and foreign ores combined) reported in Reference 2. The activity indicator for copper ore crushing was the gross weight of copper ore produced on a dry

weight basis obtained from Reference 3a. The activity indicator for zinc ore crushing was the gross weight of zinc ore produced on a dry weight basis reported in Reference 4a. The activity indicator for lead ore crushing was the gross weight of lead ore produced on a dry weight basis obtained from Reference 4.

3.23.3   Emission Factor

The TSP emission factors for iron ore mining were obtained from Reference 5. The TSP emission factors for taconite processing were the sum of the emission factors for nine individual processes obtained from Reference 6a. The processes and SCCs are listed in Table 3.23-1. The TSP emission factors were obtained from Reference 6b for bauxite crushing (SCC 3-03-000-01). The PM-10 emission factors for these sources were obtained from Reference 7.

The TSP emission factors for zinc ore crushing and lead ore crushing were obtained from Reference 6c. The PM-10 emission factors were obtained from Reference 7 or Table 3.1-3 of this report.

The emission factors for copper ore crushing were the sum of the emission factors for seven individual processes. These processes and the corresponding SCCs are listed in Table 3.23-2. The TSP emission factors were obtained from Reference 5 with the exception of the copper ore crushing emission factors which were obtained from Reference 6c. The PM-10 emission factors for all seven processes were obtained from Reference 7 or Table 3.1-3 of this report.

3.23.4   Control Efficiency

The TSP control efficiencies for taconite processing and bauxite crushing were derived from Reference 8 or Reference 9 using Equation 3.23-2.

$$ CE \quad = \quad \left[\frac{(UE - AE)}{UE} \right] \qquad \text{(Eq. 3.23-2)} $$

where: CE =   control efficiency
         UE =   emissions before control
         AE =   emissions after control

The TSP control efficiencies for copper, zinc, and lead ore crushing were based on engineering judgment. No additional basis for the yearly variations in these control efficiencies is currently available.

The PM-10 control efficiencies for taconite processing and bauxite crushing for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 10. During these years, any changes in the corresponding TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

No control efficiencies were applied to the activity data to estimate PM-10 emissions from iron ore mining and copper, zinc, and lead ore crushing.

3.23.5   References

1. *Minerals Yearbook*, Iron Ore. Bureau of Mines, U.S. Department of the Interior, Washington, DC.
    Annual.
    a.   Table entitled, "Usable Iron Ore Produced in the U.S. in 19xx by District, State, & Type of
          Product."

2. *Minerals Yearbook*, Bauxite and Alumina. Bureau of Mines, U.S. Department of the Interior,
    Washington, DC. Annual.

3. *Minerals Yearbook*, Copper. Bureau of Mines, U.S. Department of the Interior, Washington, DC.
    Annual.
    a.   Table entitled, "Salient Copper Statistics."

4. *Minerals Yearbook*, Lead. Bureau of Mines, U.S. Department of the Interior, Washington, DC.
    Annual.
    a.   Table entitled, "Production of Lead and Zinc in Terms of Recoverable Metals, in U.S. in 19xx,
          by State."

5. *Assessment of Fugitive Particulate Emission Factors for Industrial Processes*. EPA-450/3-78-107.
    U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1978.

6. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*.
    U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
    a.   Volume I, Table 8.22-1
    b.   Volume I, Table 7.1-2
    c.   Volume I, Table 7.18-1

7. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listings for Criteria Air
    Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental
    Protection Agency, Research Triangle Park, NC. March 1990.

8. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem*. Unpublished
    computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S.
    Environmental Protection Agency, Research Triangle Park, NC. Annual.

9. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*.
    Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and
    Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

10. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for
    Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency,
    Research Triangle Park, NC. October 1990.

**Table 3.23-1. PM-10 and TSP Emission Factor
SCCs for Taconite Processing**

SCC	Description
3-03-023-01	Primary Crushing
3-03-023-02	Fines Crushing
3-03-023-04	Ore Transfer
3-03-023-07	Bentonite Storage
3-03-023-08	Bentonite Blending
3-03-023-09	Traveling Grate Feed
3-03-023-10	Traveling Grate Discharge
3-03-023-12	Indurating Furnace
3-03-023-16	Pellet Transfer

**Table 3.23-2. PM-10 and TSP Emission Factor
Processes for Copper Ore Crushing**

Description
Open pit/overburden removal
Drill/blast
Loading
Truck dumping
Transfer/conveying
Copper Ore Crushing
Storage

3.24   PETROLEUM AND RELATED INDUSTRIES - OIL AND GAS PRODUCTION: 06-01

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source categories.

Tier I Category	Tier II Category	Tier II Subcategory
(06) PETROLEUM AND RELATED INDUSTRIES	(01) Oil and Gas Production	Petroleum Marketing and Production - crude oil and natural gas Sulfur Recovery Plants - natural gas fields

3.24.1   Technical Approach

The SO_2 and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated only for SO_2 and VOC from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, the activity indicator for SO_2 emissions from natural gas fields was expressed in thousand short tons and the emission factor was expressed in metric pounds/short ton. For VOC emissions from crude oil production and natural gas liquids, the activity indicators were expressed in millions barrels and the emission factors were expressed in metric pounds/thousand barrels.

The procedures for determining activity indicators and emission factors were used for the years 1940, 1950, 1960, and 1970 through 1984 for both pollutants.

3.24.2   Activity Indicator

The activity indicator for the SO_2 emissions from natural gas fields was the quantity of sulfur recovered by natural gas plants obtained from Reference 1. The activity indicator for VOC emissions from crude oil production was the total U.S. field production including lease condensate obtained from Reference 2a. The activity indicator for VOC emissions from natural gas liquids category was the total field production of natural gas plant liquids was obtained from Reference 2a.

3.24.3   Emission Factor

The SO_2 emission factor for natural gas fields was based on the actual emissions for the SCCs 3-01-032-01 through 3-01-032-04. These emission data were summed and divided by the sum of the corresponding operating rates. All data was obtained from Reference 3 or Reference 4.

The VOC emission factor for crude oil production was obtained from Reference 5. The VOC emission factor for natural gas liquids was obtained from Reference 5.

3.24.4   Control Efficiency

No control efficiencies were applied to the activity data to estimate the SO_2 and VOC emissions from the sources included in this Tier II category.

3.24.5   References

1. *Minerals Industry Surveys*, Sulfur. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Monthly.

2. *Petroleum Supply Annual*. DOE/EIA-0340(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
    (a) Table 1

3. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

4. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

5. *Control Techniques for VOC Emissions from Stationary Sources*. EPA-450/3-85-008. U.S. Environmental Protection Agency, Research Triangle Park, NC. September, 1985.

3.25   PETROLEUM AND RELATED INDUSTRIES - PETROLEUM REFINERIES AND RELATED INDUSTRIES: 06-02

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source categories.

Tier I Category	Tier II Category	Tier II Subcategory
(06) PETROLEUM AND RELATED INDUSTRIES	(02) Petroleum Refineries and Related Industries	FCC, TCC, and Flares Sulfur Recovery Compressors Blow Down Systems Process Drains Vacuum Jets and Cooling Towers

3.25.1   Technical Approach

The CO, NO_x, PM-10, TSP, SO_2, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators for CO, NO_x, PM-10, TSP, and SO_2 emissions were expressed in thousand short tons and emission factors were expressed in metric pounds/short ton. For VOC emissions, activity indicators were expressed in millions barrels and emission factors were expressed in metric pounds/thousand barrels. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to Equation 3.25-1.

$$PM\text{-}10 \ Emissions_{year} \ = \ PM\text{-}10 \ Emissions_{1975} \ \times \ \frac{TSP \ Emissions_{year}}{TSP \ Emissions_{1975}} \qquad \text{(Eq. 3.25-1)}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.25.2   Activity Indicator

3.25.2.1 CO Emissions

The activity indicators for Fluid Catalytic Cracking (FCC) and Thermal Catalytic Cracking (TCC) units in petroleum refineries were based on the separate FCC and TCC capacities. The TCC capacity was obtained from Reference 1 as the value reported in the "other" category for cnt cracking fresh feed charge capacity. (Sum of values for individual refineries.) The FCC capacity was not available directly, but was calculated as the difference between the total capacity and the TCC capacity. Total capacity of catalytic cracking fresh feed in bbl/stream day was obtained from Reference 1. This value was converted to bbl/calendar year by multiplying by 328.5 (365 days/year x 0.9 calendar day/stream day).

The FCC and TCC capacities were converted to throughput data using the refinery operating ratio. This ratio was obtained from Reference 2a and converted to a percentage. Capacities were multiplied by this refinery operating percentage to obtain the corresponding throughputs. The FCC and TCC throughputs were used as the activity indicators.

3.25.2.2 NO_x Emissions

The activity indicators for FCC and TCC in petroleum refineries were based on the separate FCC and TCC capacities. The TCC capacity was obtained from Reference 1 as the value reported in the "other" category for cnt cracking fresh feed charge capacity. (Sum of values for individual refineries.) The FCC capacity was not available directly, but was calculated as the difference between total capacity and TCC capacity. Total capacity of catalytic cracking fresh feed in bbl/stream day was obtained from Reference 1. This value was converted to bbl/calendar year by multiplying by 328.5 (365 days/year x 0.9 calendar day/stream day).

The FCC and TCC capacities were converted to throughput data using the refinery operating ratio. This ratio was obtained from Reference 2a and converted to a percentage. Capacities were multiplied by this refinery operating percentage to obtain the corresponding throughputs. The FCC and TCC throughputs were used as the activity indicators.

The activity indicator for flares in petroleum refineries was based on total refinery crude capacity in bbl/calendar day obtained from Reference 1. This value was multiplied by 365 to convert it to an annual value. The activity indicator was calculated by multiplying the capacity by the VOC control efficiency for blow down systems, expressed as a percentage. The derivation of this control efficiency is described in section 3.25.4.4.

3.25.2.3 PM-10 and TSP Emissions

The activity indicators for FCC and TCC in petroleum refineries were based on the separate FCC and TCC capacities. The TCC capacity was obtained from Reference 1 as the value reported in the "other" category. The FCC capacity was not available directly, but was calculated as the difference between total capacity and TCC capacity. Total capacity of catalytic cracking fresh feed in bbl/stream day was obtained from Reference 1. This value was converted to bbl/calendar year by multiplying by 328.5 (365 days/year x 0.9 calendar day/stream day).

The FCC and TCC capacities were converted to throughput data using the refinery operating ratio. This ratio was obtained from Reference 2a and converted to a percentage. Capacities were multiplied by this refinery operating percentage to obtain the corresponding throughputs. The FCC and TCC throughputs were used as the activity indicators.

3.25.2.4 SO$_2$ Emissions

The activity indicator for sulfur recovery plants at refineries was the quantity of sulfur recovered by petroleum refineries obtained from Reference 3.

The activity indicators for FCC and TCC in petroleum refineries were based on the separate FCC and TCC capacities. The TCC capacity was obtained from Reference 1 as the value reported in the "other" category. The FCC capacity was not available directly, but was calculated as the difference between total capacity and TCC capacity. Total capacity of catalytic cracking fresh feed in bbl/stream day was obtained from Reference 1. This value was converted to bbl/calendar year by multiplying by 328.5 (365 days/year x 0.9 calendar day/stream day).

The FCC and TCC capacities were converted to throughput data using the refinery operating ratio. This ratio was obtained from Reference 2a and converted to a percentage. Capacities were multiplied by this refinery operating percentage to obtain the corresponding throughputs. The FCC and TCC throughputs were used as the activity indicators.

The activity indicator for flares in petroleum refineries was based on the total refinery crude capacity in bbl/calendar day obtained from Reference 1. This value was multiplied by 365 to convert it to an annual value. The activity indicator was calculated by multiplying the capacity by the VOC control efficiency for blow down systems, expressed as a percentage. The derivation of this control efficiency is described in section 3.25.4.4.

3.25.2.5 VOC Emissions

The activity indicators for FCC and TCC in petroleum refineries were based on the separate FCC and TCC capacities. The TCC capacity was obtained from Reference 1 as the value reported in the "other" category. The FCC capacity was not available directly, but was calculated as the difference between total capacity and TCC capacity. Total capacity of catalytic cracking fresh feed in bbl/stream day was obtained from Reference 1. This value was converted to bbl/calendar year by multiplying by 328.5 (365 days/year x 0.9 calendar day/stream day).

The FCC and TCC capacities were converted to throughput data using the refinery operating ratio. This ratio was obtained from Reference 2a and converted to a percentage. Capacities were multiplied by this refinery operating percentage to obtain the corresponding throughputs. The FCC and TCC throughputs were used as the activity indicators.

The activity indicators for the petroleum refinery process operations of compressor, blow down systems, process drains, cooling towers, and miscellaneous processes were the total crude capacity reported in Reference 1. The capacity, expressed in bbl/calendar day, was multiplied by 365 to convert it to an annual figure. The activity indicator for vacuum jets was the total vacuum distillation capacity

obtained from Reference 1. The capacity, expressed in bbl/stream day, was multiplied by the following factor to convert it to an annual value: 365 days/year x 0.95 calendar day/stream day.

3.25.3   Emission Factor

3.25.3.1 CO Emissions

The emission factors for FCC and TCC in petroleum refineries were obtained from Reference 4a for SCCs 3-06-002-01 and 3-06-003-01, respectively. In this reference, TCC was categorized as moving-bed catalytic cracking units.

3.25.3.2 NO_x Emissions

The emission factors for FCC, TCC, and flares in petroleum refineries were obtained from Reference 4a for SCCs 3-06-002-01, 3-06-003-01, and 3-06-004-01, respectively. In this reference, TCC was categorized as moving-bed catalytic cracking units and flares were categorized as blow down system with vapor recovery.

3.25.3.3 PM-10 and TSP Emissions

The TSP emission factors for FCC and TCC in petroleum refineries were obtained from Reference 4a for SCCs 3-06-002-01 and 3-06-003-01, respectively. In this reference, TCC was categorized as moving-bed catalytic cracking units. The PM-10 emission factors for these sources were obtained from Reference 5. For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from these emission sources.

3.25.3.4 SO_2 Emissions

The emission factor for sulfur recovery plants at refineries was based on SCCs 3-01-032-01 through 3-01-032-04. These emission data were summed and divided by the sum of the corresponding operating rates. All data was obtained from Reference 6 or Reference 7.

The emission factors for FCC, TCC, and flares in petroleum refineries were obtained from Reference 4a for SCCs 3-06-002-01, 3-06-003-01, and 3-06-004-01, respectively. In this reference, TCC was categorized as moving-bed catalytic cracking units and flares were categorized as blow down system with vapor recovery.

3.25.3.5 VOC Emissions

The emission factors for FCC and TCC in petroleum refineries were obtained from Reference 1. These emission factors were converted to a reactive basis using the profile SDM 306002 obtained from Reference 8.

The emission factors for the petroleum refinery process operations of blow down systems, process drains, vacuum jets, cooling towers, and miscellaneous processes were obtained from Reference 1. The emission factor for compressors was obtained from Reference 9.

The emission factors were converted to a reactive basis using profiles from Reference 8, except for the emission factor for vacuum jets for which the profile was obtained from Reference 10. Compressors, blow down systems, process drains, and cooling towers were converted to a reactive basis using the profiles SDM 202002, SDM 306009, SDM 306005, and SDM 306007, respectively, obtained from Reference 8. The emission factor for miscellaneous processes was converted using the profiles SDM 306008A, 8P, 8Y 8Z (Aug), and 8N.

3.25.4 Control Efficiency

3.25.4.1 CO Emissions

The control efficiencies for FCC and TCC in petroleum refineries were derived from the actual and uncontrolled emissions reported in Reference 6 or Reference 7 according to Equation 3.25-2.

$$CE \;=\; \left[\frac{(UE-AE)}{UE} \right] \tag{Eq. 3.25-2}$$

where: CE = control efficiency
UE = uncontrolled emissions
AE = actual (controlled) emissions

3.25.4.2 NO_x Emissions

No control efficiencies were applied to the activity data to estimate the NO_x emissions from the petroleum refinery sources included in this Tier II category.

3.25.4.3 PM-10 and TSP Emissions

The TSP control efficiencies for FCC and TCC in petroleum refineries were derived from the actual and uncontrolled emissions reported in Reference 6 or Reference 7 according to Equation 3.25-2. The PM-10 control efficiencies for these processes for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 11. During these years, any changes in the corresponding TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

3.25.4.4 VOC Emissions

The control efficiencies for FCC and TCC in petroleum refineries were assumed to be 95 percent of the corresponding CO control efficiencies.

For the years 1970 through 1984, the emission factors for the petroleum refinery process operations of blow down systems, process drains, and vacuum jets were based on the controlled and uncontrolled emission factors. The controlled emission factors were estimated using weighted averages of emission factors for "old" refinery capacity (pre-1970) and "new" refinery capacity where the "old" and "new"

capacities for used as weighting factors. A detailed description of the calculation procedure is presented below.

The first step in this procedure was the development of the breakdown of the refineries capacity into "old" and "new". For blow down systems and process drains, the total crude oil capacity of refineries was obtained from Reference 1 for the year under study and for the previous year. The difference between total capacity for the year under study and capacity from the previous year was assumed to be the new capacity for the year under study. If the difference was negative, the new capacity was assumed to be zero.

In order to calculate the old capacity, the NSPS capacity was calculated. This was done by adding the new capacity for the year under study to 1 percent of the total capacity from the previous year. This sum, the NSPS capacity, was subtracted from the total capacity for the year under study, resulting in the old capacity.

The same procedure was used to estimate the old and new capacities for vacuum jets. In place of the total crude oil capacity, the total vacuum distillation capacity obtained from Reference 1 was used.

For each of the three processes, two controlled emission factors were used to calculate a weighted average controlled emission factor. The average 1970 emission factor represented the emission rate of older operations and, therefore, was weighted by the old capacity. The NSPS emission factor, applicable to newer operation, was weighted by the new capacity. The 1970 and NSPS emission factors for each subcategory are presented in Table 3.25-1, along with the corresponding uncontrolled emission factors. The calculation of the weighted average controlled emission factors is summaries in Equation 3.25-3.

$$EF_{Controlled} = \frac{(Capacity_{old} \times EF_{old}) + (Capacity_{new} \times EF_{new})}{(Capacity_{old} + Capacity_{new})} \qquad \text{(Eq. 3.25-3)}$$

where: EF =   emission factor

The control efficiency for each process was calculated as the percentage difference between the controlled emission factor calculated according to the methodology above and the uncontrolled emission factors presented in Table 3.25-1. This calculation is summarized in Equation 3.25-4.

$$CE = \frac{(EF_{Uncontrolled} - EF_{Controlled})}{EF_{Uncontrolled}} \qquad \text{(Eq. 3.25-4)}$$

where: CE =   control efficiency
         EF =   emission factor

For the years 1940, 1950, and 1960, the procedure for determining the control efficiencies for blow down systems, process drains, and vacuum jets is currently unavailable.

No control efficiencies were applied to the activity data to estimate VOC emissions from compressors, cooling towers, or miscellaneous processes used in petroleum refinery process operations.

3.25.5   References

1. *Oil and Gas Journal*. Annual Refining Survey, P.O. Box 2601, Clinton, IA. Annual.

2. *Survey of Current Business*. Bureau of Economic Analysis, U.S. Department of Commerce, Washington, DC. Annual.
    (a) Table containing information on Petroleum, Coal, and Products

3. *Minerals Industry Surveys*, Sulfur. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Monthly.

4. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
    (a)   Volume I, Table 9.1-1

5. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listings for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

6. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

7. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

8. *Volatile Organic Compound (VOC) Species Data Manual*. EPA-450/4-80-015. U.S. Environmental Protection Agency, Research Triangle Park, NC. July 1980.

9. *Air Pollution Aspects of Petroleum Refining*. PHS-763. U.S. Public Health Service, Washington, DC.

10. *Control Techniques Guidelines*. EPA-450/2-77-025. U.S. Environmental Protection Agency, Washington, DC. 1977.

11. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.

Table 3.25-1. Emission Factors Used in the Calculation of the Control Efficiencies for the Blow Down Systems, Process Drains, and Vacuum Jets Subcategories

Subcategories	Emission Factors (lb/10^6 bbl)		
	1970	**NSPS**	**Uncontrolled**
Blow down Systems	178.84	5.26	263
Process Drains	205.2	57.0	570
Vacuum Jets	108.75	0.0	145

3.26   PETROLEUM AND RELATED INDUSTRIES - ASPHALT MANUFACTURING: 06-03

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source categories.

Tier I Category	Tier II Category	Tier II Subcategory
(06) PETROLEUM AND RELATED INDUSTRIES	(03) Asphalt Manufacturing	Batching - dryers and fugitives Roofing - blowing and felt saturation Blowing

3.26.1   Technical Approach

The PM-10, TSP, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated only for particulates and VOC from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators for PM-10 and TSP emissions were expressed in thousand short tons and emission factors were expressed in metric pounds/short ton. For VOC emissions, the activity indicator was expressed in millions barrels and the emission factor was expressed in metric pounds/thousand barrels. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies for VOC were used for the years 1940, 1950, 1960, and 1970 through 1984 and for TSP for the years through 1992. For PM-10, these procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to Equation 3.26-1.

$$PM\text{-}10\ Emissions_{year}\ =\ PM\text{-}10\ Emissions_{1975}\ \times\ \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}} \qquad \text{(Eq. 3.26-1)}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.26.2   Activity Indicator

The total amount of asphalt and road oil supplied, expressed in barrels, was obtained from Reference 1 and was multiplied by 2.29. This result was used as the PM-10 and TSP activity indicators for the asphalt batching operations of dryers and fugitive processes. The activity indicators for the asphalt

roofing operations of blowing and felt saturation were the total domestic consumption of asphalt obtained from Reference 2.

The VOC activity indicator for asphalt blowing was the total crude capacity, expressed in barrels/day obtained from Reference 3. This daily value was multiplied by 365 to convert to an annual figure.

3.26.3   Emission Factor

The PM-10 and TSP emission factors for asphalt batching dryers were the weighted average of the emission factors for rotary dryers, conventional plant (SCC 3-05-002-01), drum dryers, and drum mix plant (SCC 3-05-002-05). The TSP emission factors were obtained from References 4a and 4b and the PM-10 emission factors were obtained from Reference 5. These emission factors were weighted by the number of records in Reference 6 or Reference 7 corresponding to the rotary and drum dryer SCCs.

The PM-10 and TSP emission factors for asphalt batching fugitive processes were obtained from Reference 5 and Reference 8, respectively.

The TSP emission factors for blowing operations for asphalt roofing were obtained from Reference 4c for saturant (SCC 3-05-001-01) and coating (SCC 3-05-001-02). The PM-10 emission factors were obtained from Reference 5. Weighted averages of these two emission factors were calculated by weighting the saturant emission factor by 95 percent and the coating emission factor by 5 percent.

The TSP emission factors for felt saturation operations in asphalt roofing were obtained from Reference 4c for dipping only (SCC 3-05-001-03) and dipping/spraying (SCC 3-05-001-04). The PM-10 emission factors were obtained from Reference 5. Weighted average of these emission factors were calculated by weighting the dipping only emission factors by two-thirds and the dipping/spraying emission factors by one-third.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier II category.

The VOC emission factor for asphalt blowing was obtained from Reference 4.

3.26.4   Control Efficiency

The TSP control efficiencies for asphalt batching dryers were the weighted average of the control efficiencies for drum and rotary dryers derived from Reference 6 or Reference 7 using Eqiatopm 3.26-2. These control efficiencies were weighted in the same manner as the drum and rotary dryer emission factors.

$$CE \quad = \quad \left[\frac{(UE - AE)}{UE} \right] \qquad \text{(Eq. 3.26-2)}$$

where: CE =   control efficiency
             UE =   uncontrolled emissions
             AE =   controlled emissions

The 1980 TSP control efficiency for asphalt batching fugitive processes was calculated using data from Reference 3 for the SCCs 3-05-002-03 and 3-05-002-04. For subsequent years, it was assumed that the fugitive control efficiencies changed in proportion to the changes in dryer control efficiencies. No procedure for determining the control efficiencies prior to 1980 is currently available.

The TSP control efficiencies for blowing operations in asphalt roofing were the weighted averages of the control efficiencies for saturant and coating derived from Reference 6 or Reference 7 using the equation given above. These individual control efficiencies were weighted in the same manner as the saturant and coating emission factors.

The TSP control efficiencies for felt saturation operation in asphalt roofing were the weighted averages of the control efficiencies for dipping and dipping/spraying derived from Reference 6 or Reference 7 using the equation given above. These individual control efficiencies were weighted in the same manner as the dipping and dipping/spraying emission factors.

The PM-10 control efficiencies for asphalt batching dryers and for blowing and felt saturation operations for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 9. During these years, any changes in the corresponding TSP control efficiencies from the 1985 TSP control efficiency values were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions from asphalt roofing operations or asphalt batching fugitive processes.

No control efficiencies were applied to the activity data to estimate VOC emissions from asphalt blowing.

3.26.5   References

1. *Petroleum Supply Annual*. DOE/EIA-0340(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.

2. *Asphalt Usage United States & Canada*. The Asphalt Institute, College Park, MD. Annual.

3. *Oil and Gas Journal*. Annual Refining Survey, P.O. Box 2601, Clinton, IA. Annual.

4. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
   a.   Volume I, Table 8.1-1
   b.   Volume I, Table 8.1-3
   c.   Volume I, Table 8.2-1

5. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listings for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

6. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem.* Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

7. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS).* Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

8. *Assessment of Fugitive Particulate Emission Factors for Industrial Processes.* EPA-450/3-78-107. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1978.

9. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.

3.27   OTHER INDUSTRIAL PROCESSES - AGRICULTURE, FOOD, AND KINDRED PRODUCTS: 07-01

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source categories.

Tier I Category	Tier II Category	Tier II Subcategory
(07) OTHER INDUSTRIAL PROCESSES	(01) Agriculture, Food, and Kindred Products	Cotton ginning, cattle feedlots, alfalfa dehydrators, country elevators, terminal elevators, feed mills, grain milling (wheat, corn-dry, corn-wet, rice, soybeans) Bakeries, fermentation, and vegetable oil

3.27.1   Technical Approach

The PM-10, TSP, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated only for particulates and VOC from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, the activity indicators were expressed in thousand short tons and the emission factors were expressed in metric pounds/short ton. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies for VOC were used for the years 1940, 1950, 1960, and 1970 through 1984 and for TSP for the years through 1992. For PM-10, these procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to Equation 3.27-1.

$$PM\text{-}10 \; Emissions_{year} \; = \; PM\text{-}10 \; Emissions_{1975} \; \times \; \frac{TSP \; Emissions_{year}}{TSP \; Emissions_{1975}} \qquad \text{(Eq. 3.27-1)}$$

This calculation was used in place of estimating the emissions based on activity indicators, emission factors, and control efficiencies.

3.27.2   Activity Indicator

3.27.2.1 PM-10 and TSP Emissions

The activity indicator for cotton ginning was the number of running bales obtained from Reference 1a.

The cattle feedlot activity indicator was based on the number of cattle and calves slaughtered, expressed in thousands, reported in Reference 1b. This value was multiplied by 0.46 to determine the final activity indicator.

The activity indicator for alfalfa dehydrators was total production obtained from Reference 2.

The activity indicators for country elevators and terminal elevators were based on the total production of five major grains. Total production of sorghum was obtained from Reference 3. Total productions of wheat, corn, oats, and barley were each obtained from Reference 1b. Production figures for each grain were converted from bushels to total weight using the conversion factors listed in Table 3.27-1. The production figures for the five grains were summed and multiplied by 0.8. This grain production by weight was the activity indicator for both country elevators and terminal elevators.

The activity indicator for feed mills is the total consumption of wheat, corn, oats, barley, sorghum, and alfalfa meal. When the year under study was a census year, total consumption data (SIC 2048) was obtained from Reference 2. For a noncensus year, grain consumption by feed mills was estimated using the total grain production as determined for the country elevator subcategory. Total production was multiplied by the ratio of total grain production to total grain consumption data (SIC 2048) obtained for the previous census year.

The activity indicator for the wheat milling was the total quantity of grindings of wheat expressed in thousands of bushels reported in Reference 1a. The quantity was converted to weight using the wheat conversion factor presented in Table 3.27-1.

The activity indicator for the dry corn milling was the total production of dry corn. When the year under study was a census year, the total dry corn production was obtained from Reference 2. For noncensus years, the dry corn production was calculated by multiplying the total corn production obtained from Reference 1b for the year under study by the factor 0.021. For the years 1940 through 1973, this multiplicative factor, as well as a procedure for determining the factor, is currently unavailable.

The activity indicator for wet corn milling was determined in the same manner as dry corn milling. The only difference being the use of 0.059 as the multiplicative factor for noncensus years after 1974.

The activity indicator for rice was the total rice production. The production figure was obtained as the total shipments from mills in southern states and California or the total production reported in Reference 1b.

The activity indicator for soybeans was based on the total soybean production as obtained from Reference 3. This value was converted from bushels to weight using the conversion factor for wheat

---

given in Table 3-27-1. It was assumed that 70 percent of the total production was domestic consumption. The final activity indicator for soybeans represented only the domestic consumption.

3.27.2.2 VOC Emissions

The activity indicator for bakeries was the production of wheat flour obtained from Reference 1b. This value, expressed in thousand sacks, was multiplied by 27.21 tons bread baked/10^6 sacks.

The activity indicator for the fermentation processes was based on the stocks of distilled spirits and production of beer reported in Reference 1b. Stocks of distilled spirits were converted to metric pounds by the factor 0.1814 metric lb/gal. Beer production figure was converted to metric pound using the factor 0.06 metric lb/bbl. The activity indicator was the sum of distilled spirits and beer production figures.

The activity indicator for vegetable oil subcategory was the refined oil production for soybean, cotton seed, corn, and coconut obtained from Reference 4.

3.27.3   Emission Factor

3.27.3.1 PM-10 and TSP Emissions

The emission factors for cotton ginning were the sum of the emission factors for the following four processes: unleading fan (3-02-004-01), seed cotton cleaning system (SCC 3-02-004-02), stick/burr machine (SCC 3-02-004-03), and miscellaneous (SCC 3-02-004-04). These emission factors were obtained from Reference 5a for TSP and from Reference 6 from PM-10.

The PM-10 and TSP emission factors for cattle feedlots (SCC 3-02-020-01) were obtained from Reference 6 and Reference 5b, respectively.

The emission factors for alfalfa dehydrator were the sum of the emission factors from three processes: primary cyclone and dryer (SCC 3-02-001-02), meal collector (SCC 3-02-001-03), and pellet cooler (SCC 3-02-001-04). The emission factors for these processes were obtained from Reference 5c for TSP and from Reference 6 for PM-10.

The emission factors for country elevators were the sum of the emission factors from six process listed in Table 3.27-2. The emission factors for terminal elevators were the sum of the emission factors from seven process listed in Table 3.27-3. The PM-10 and TSP emission factors for the elevator processes were obtained from Reference 6 and Reference 5d, respectively.

The emission factors for feed mills were the sum of the emission factors from five process listed in Table 3.27-4. The emission factors for these processes were obtained from Reference 5e for TSP and from Reference 6 for PM-10.

The PM-10 and TSP emission factors for wheat milling were based on the emission factors obtain from Reference 6 and Reference 5e, respectively, for the following three processes: receiving (SCC 3-02-007-31), precleaning/handling (SCC 3-02-007-32), and millhouse (3-02-007-34). It was assumed that a

99 percent control applied to the millhouse emission factor. The resulting controlled emission factors for the millhouse process were added to the other emission factors to obtain the final PM-10 and TSP emission factors.

The PM-10 and TSP emission factors for dry corn were the sum of the emission factors obtain from Reference 6 and Reference 5e, respectively, for the following four processes: receiving (SCC 3-02-007-41), drying (SCC 3-02-007-42), precleaning/handling (SCC 3-02-007-43), and cleaning (3-02-007-44). The emission factors for wet corn were the sum of the emission factors for the following three processes: receiving (SCC 3-02-007-51), handling (SCC 3-02-007-52), and cleaning (3-02-007-53). The PM-10 emission factors were obtained from Reference 6; the TSP emission factors were obtained from Reference 5e .

The PM-10 and TSP emission factors for rice were the sum of the emission factors obtain from Reference 6 and Reference 5e, respectively, for the following processes: receiving (SCC 3-02-007-71) and precleaning/handling (SCC 3-02-007-72).

The emission factors for soybeans were the sum of the emission factors from 10 processes listed in Table 3.27-5. The emission factors for these processes were obtained from Reference 5e for TSP and from Reference 6 for PM-10.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier II category.

3.27.3.2 VOC Emissions

The emission factor for bakeries was weighted average of the emission factors for sponge dough (SCC 3-02-032-01) and straight dough (SCC 3-02-032-02). These emission factors were obtained from Reference 5f. The weighting factor for sponge dough was 0.915 and for straight dough was 0.085.

The emission factor for fermentation processes was based on the assumption of complete evaporation of all volatile compounds (i.e. the emission factor was 2000 lb/ton).

The emission factor for vegetable oil was based on the 1979 emission estimates obtained from the EPA's Emission Standards and Engineering Division. The total emissions were divided by the 1977 production rate to obtain the emission factor for vegetable oil. The source of the 1977 production rate is currently unavailable.

3.27.4   Control Efficiency

3.27.4.1 PM-10 and TSP Emissions

The TSP control efficiencies for all agricultural industrial processes, excluding country and terminal elevators, were derived from Reference 7 or Reference 8 using Equation 3.27-2.

$$CE = \left[\frac{(UE-AE)}{UE}\right]$$ (Eq. 3.27-2)

where: CE = control efficiency
UE = uncontrolled emissions
AE = actual (controlled) emissions after

The TSP control efficiencies for country and terminal elevators were the weighted average of the control efficiencies for the SCCs given in Table 3.27-2 and Table 3.27-3, respectively. These individual control efficiencies were derived from Reference 7 or Reference 8 using Equation 3.27-2. The final country and terminal elevator control efficiencies were calculated using weighting factors obtained in Reference 5d.

The PM-10 control efficiencies for all agricultural industry emission sources for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 9. During these years, any changes in the corresponding TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

3.27.4.2 VOC Emissions

No control efficiencies were applied to the activity data to estimate VOC emissions from bakeries, fermentation processes, and vegetable oil production.

3.27.5   References

1. *Survey of Current Business*. Bureau of Economic Analysis, U.S. Department of Commerce, Washington, DC.
    (a) Table containing information on "textile products."
    (b) Table containing information on "food and kindred products."

2. *Census of Manufactures*. Bureau of the Census, U.S. Department of Commerce, Washington, DC. Available every 5 years.

3. *Crop Production*. GPO 20-B-S/N001/028/80029/1. Crop Reporting Board Economic Statistics & Cooperative Service, U.S. Department of Agriculture, Washington, DC. Monthly.

4. *Current Industrial Reports*, Fats and Oil. Bureau of the Census, U.S. Department of Commerce, Washington, DC. Annual.

5. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
    a. Volume I, Table 6.3-1
    b. Volume I, Table 6.15-1
    c. Volume I, Table 6.1-1

    d.   Volume I, Table 6.4-5 (column 3)
    e.   Volume I, Table 6.4-6
    f.   Volume I, Section 6.13

6.   *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listings for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

7.   *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

8.   *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

9.   Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.

Table 3.27-1. Conversion of Grain Volume (in bushels) to Weight (in pounds)

Grain	lb/bu
Wheat	60
Corn	56
Oats	32
Barley	48
Sorghum	56

Table 3.27-2. PM-10 and TSP Emission Factor SCCs for Country Elevators

SCC	Description
3-02-006-03	Cleaning
3-02-006-04	Drying
3-02-006-05	Unloading (receiving)
3-02-006-06	Loading (shipping)
3-02-006-09	Removal from bins
3-02-006-10	Headhouse (legs)

Table 3.27-3. PM-10 and TSP Emission Factor SCCs for Terminal Elevators

SCC	Description
3-02-005-03	Cleaning
3-02-005-04	Drying
3-02-005-05	Unloading (receiving)
3-02-005-06	Loading (shipping)
3-02-005-09	Tripper (gallery belt)
3-02-005-10	Removal from bins
3-02-005-11	Headhouse (legs)

Table 3.27-4. PM-10 and TSP Emission Factor SCCs for Feed Mills

SCC	Description
3-02-008-02	Receiving
3-02-008-03	Shipping
3-02-008-04	Handling
3-02-008-05	Grinding
3-02-008-06	Pellet Coolers

Table 3.27-5. PM-10 and TSP Emission Factor SCCs for Soybean Milling

SCC	Description
3-02-007-81	Receiving
3-02-007-82	Handling
3-02-007-84	Drying
3-02-007-85	Cracking/Dehulling
3-02-007-86	Hull Grinding
3-02-007-87	Bean Conditioning
3-02-007-88	Flaking
3-02-007-89	Meal Dryer
3-02-007-90	Meal Cooler
3-02-007-91	Bulk Loading

3.28   OTHER INDUSTRIAL PROCESSES - WOOD, PULP AND PAPER, AND PUBLISHING PRODUCTS: 07-03

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source categories.

Tier I Category	Tier II Category	Tier II Subcategory
(07) OTHER INDUSTRIAL PROCESSES	(03) Wood, Pulp and Paper, and Publishing Products	Pulp and Paper - kraft and sulfite Semi-Chemical Wood Pulp Production Plywood Lumber

3.28.1   Technical Approach

The CO, NO_x, PM-10, TSP, and SO_2 emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in thousand short tons and emission factors were expressed in metric pounds/short ton. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to Equation 3.28-1.

$$PM\text{-}10 \; Emissions_{year} \; = \; PM\text{-}10 \; Emissions_{1975} \; \times \; \frac{TSP \; Emissions_{year}}{TSP \; Emissions_{1975}} \qquad \text{(Eq. 3.28-1)}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.28.2   Activity Indicator

For CO and NO_x emissions, the activity indicator for kraft pulp and paper was the production value reported for sulfate obtained from Reference 1. For SO_2 emissions, the activity indicator for kraft pulp production and sulfite was the combined production of sulfate and sulfite at kraft mills and sulfite mills obtained from Reference 1.

The PM-10 and TSP activity indicators for the two pulp and paper production processes were obtained from Reference 1. The activity indicator for kraft pulp was the production value reported for sulfate and the indicator for sulfite was the production value reported for sulfite.

The PM-10 and TSP activity indicators for the two semi-chemical processes were based on the total semi-chemical wood pulp production obtained from Reference 2. It was assumed that indicator for recovery furnaces was one-third of the total production while the indicator for fluid bed reactors was 15 percent of the total production.

The PM-10 and TSP activity indicator for plywood was the softwood plywood production obtained from Reference 3a. When this reference was not available, the total plywood production was estimated using the total plywood production from Reference 4 for the census year preceding the year under study. The combined total production values of plywood from southern pine and douglas fir were obtained from Reference 2 for the census year and the year under study. Total plywood production was projected to the year under study using Equation 3.28-2.

$$P_{plywood,i} \quad = \quad P_{plywood,j} \times \left[\frac{P_{(pine\ +\ fir),i}}{P_{(pine\ +\ fir),j}} \right] \qquad\qquad \text{(Eq. 3.28-2)}$$

where: i   =   year under study
         j   =   census year
         P =   production

The PM-10 and TSP activity indicator for lumber was total lumber production obtained from Reference 5 or Reference 2.

3.28.3   Emission Factor

The CO emission factor for kraft pulp and paper processes was the sum of the emission factors for recovery furnaces (SCC 3-07-001-04) and lime kilns (SCC 3-07-001-06) obtained from Reference 6a.

The NO_x emission factor for kraft pulp processes was calculated by dividing the actual emissions by the operating rate. These values were obtained from Reference 7.

The PM-10 and TSP emission factors for the kraft process in pulp and paper production were the sum of the emissions factors for the following three processes: recovery furnaces/direct contact evaporators (SCC 3-07-001-04), smelt tanks (SCC 3-07-001-05), and lime kilns (SCC 3-07-001-06). These PM-10 and TSP emission factors were obtained from Reference 8 and Reference 9a.

The TSP emission factor for the sulfite process in pulp and paper production was obtained from Reference 10. The PM-10 emission factor was obtained from Table 3.1-3 in this report.

The TSP emission factors for the two semi-chemical processes of recovery furnaces and fluid red reactors were obtained from Reference 11. The PM-10 emission factor was obtained from Reference 8 or Table 3.1-3 of this report.

The TSP emission factor for plywood was obtained from Reference 10. The PM-10 emission factor was obtained from Table 3.1-3 of this report.

The TSP emission factor for lumber was calculated by dividing the actual emissions reported in Reference 7 by the 1977 lumber production reported in Reference 2. The PM-10 emission factor was obtained from Reference 8 or Table 3.1-3 of this report.

The SO_2 emission factor for kraft pulp production and sulfite was the weighted sum of the emission factors for kraft pulp production and for sulfite mills. The emission factor for kraft pulp production was obtained from Reference 9a. The sulfite mills emission factor was calculated from the controlled and uncontrolled sulfite mills emission factors of 20 lb/ton and 52 lb/ton, respectively. These emission factors were obtained from Reference 10. Assuming the particulate control efficiency was 0.90 for sulfite mills, the controlled emission factor was multiplied by 0.9 and the uncontrolled emission factor by 0.1. The resulting products were summed. Weighting factors for summing the emission factors for kraft pulp production and sulfite mills were the relative production levels obtained from Reference 1.

3.28.4   Control Efficiency

No control efficiencies were applied to the activity data to estimate CO, NO_x, or SO_2 emissions from the pulp and paper sources included in this Tier II category.

The TSP control efficiencies for the pulp and paper, plywood, and lumber production processes were derived from Reference 12 or Reference 13 using Equation 3.28-3. The TSP control efficiencies for the semi-chemical processes were assumed to be equal to the control efficiencies for the kraft process in pulp and paper production.

$$CE \quad = \quad \left[\frac{(UE - AE)}{UE} \right]$$ (Eq. 3.28-3)

where: CE = control efficiency
UE = uncontrolled emissions
AE = actual (controlled) emissions after

The PM-10 control efficiencies for kraft processes in pulp and paper production and fluid red reactors in semi-chemical production for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 14. During these years, any changes in the corresponding TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

No control efficiencies were applied to the activity data to estimate PM-10 emissions from sulfite processes in pulp and paper production and recovery furnaces in semi-chemical production. For plywood and lumber production, no control efficiencies were applied in the estimation of PM-10 and TSP emissions.

3.28.5   References

1. *Current Industrial Reports*, Pulp, Paper and Board. Bureau of the Census, U.S. Department of Commerce, Washington, DC. Annual.

2. *Survey of Current Business*. Bureau of Economic Analysis, U.S. Department of Commerce, Washington, DC. Annual.

3. *Current Industrial Reports*, Softwood Plywood
    (a)   Table: Production, Quantity and Value of Shipments of Softwood Plywood

4. *Census of Manufactures*. U.S. Department of Commerce, Bureau of the Census, Washington, DC. (available every 5years)

5. *Current Industrial Report*s, Lumber Production and Mill Stocks. Bureau of the Census, U.S. Department of Commerce, Washington, DC. Annual.

6. *Compilation of Air Pollutant Emission Factors, Third Edition, Supplements 1 through 14, AP-42*. NTIS PB-275525. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1977.
    a.   Volume I, Table 10.1.2-1

7. *Computer Retrieval, NE257 report, by Source Classification Code (SCC) from the National Emission Data System (NEDS)*. Unpublished computer report. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. February 9, 1980.

8. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listing for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

9. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
    a.   Volume I, Table 10.1-1

10. *Compilation of Air Pollutant Emission Factors, Third Edition, and Supplements 1-14, AP-42*. NTIS PB-275525. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1977.

11. *Particulate Pollution System Study*. U.S. Environmental Protection Agency. Prepared by Midwest Research Institute, Kansas City, MO. 1970.

12. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

13. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS).* Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

14. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.

3.29   OTHER INDUSTRIAL PROCESSES - RUBBER AND MISCELLANEOUS PLASTIC PRODUCTS: 07-04

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source category.

Tier I Category	Tier II Category	Tier II Subcategory
(07) OTHER INDUSTRIAL PROCESSES	(04) Rubber and Miscellaneous Plastic Products	Tires

3.29.1   Technical Approach

The VOC emissions included in this Tier category were the emissions from the source category listed above. Emissions were estimated only for VOC from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, the activity indicator was expressed in thousand short tons and the emission factor was expressed in metric pounds/short ton.

The procedures for determining activity indicators and emission factors were used for the years 1940, 1950, 1960, and 1970 through 1984.

3.29.2   Activity Indicator

The activity indicator for tires was the production of pneumatic casing obtained from Reference 1a.

3.29.3   Emission Factor

The VOC emission factor for tires was the sum of the emission factors for the processes listed in Table 3.29-1 and were extracted from Reference 2. These emission factors were expressed as lbs/1,000 tires. The summed emission factor was converted to lbs/ton, assuming that 1,000 tires weigh one ton.

3.29.4   Control Efficiency

No control efficiencies were applied to the activity data to estimate VOC emissions from tire production.

3.29.5   References

1. *Survey of Current Business*. Bureau of Economic Analysis, U.S. Department of Commerce, Washington, DC.
    (a) Table containing information on "rubber and rubber products."

2. *Control Techniques Guidelines*. EPA-450/2-77-025. U.S. Environmental Protection Agency, Washington, DC. 1977.

Table 3.29-1. VOC Emissions Factor SCCs for Tire Production

SCC	Description
3-08-001-01	Undertread & Sidewall Cementing
3-08-001-02	Bead Dipping
3-08-001-03	Bead Swabbing
3-08-001-04	Tire Building
3-08-001-05	Tread End Cementing
3-08-001-06	Green Tire Spraying
3-08-001-07	Tire Curing

3.30   OTHER INDUSTRIAL PROCESSES - MINERAL PRODUCTS: 07-05

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source categories.

Tier I Category	Tier II Category	Tier II Subcategory
(07) OTHER INDUSTRIAL PROCESSES	(05) Mineral Products	Mineral Products (cement, bricks, clay, concrete, glass, gypsum, and lime) Mining Operations (coal, sand and gravel, stone and rock, phosphate rock, clay, and potash) Chemical Industry (fertilizers - rock pulverization) Asphalt Roofing

3.30.1   Technical Approach

The CO, NO_x, PM-10, TSP, SO_2, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in thousand short tons and emission factors were expressed in metric pounds/short ton. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to Equation 3.30-1.

$$PM\text{-}10\ Emissions_{year} = PM\text{-}10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}} \qquad \text{(Eq. 3.30-1)}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.30.2   Activity Indicator

3.30.2.1 CO Emissions

The activity indicator for asphalt roofing was the total domestic consumption obtained from Reference 1.

The activity indicators for kiln and fugitive processes in lime production were the lime production obtained from Reference 2.

3.30.2.2 NO$_x$ Emissions

The activity indicator for cement manufacturing was the total quantity of cement production as obtained from Reference 3.

The activity indicator for glass manufacturing was based on the sum of total production of flat glass obtained from Reference 4 and the net packed weight of glass containers obtained from Reference 5. The resulting value was multiplied by 1.10 to account for miscellaneous glass products.

The activity indicator for lime kiln and fugitive processes was the lime production obtained from Reference 2.

3.30.2.3 PM-10 and TSP Emissions

3.30.2.3.1   Mineral Products Industry —
The activity indicators for the three cement manufacturing processes were the total quantity of cement production as obtained from Reference 3.

The total brick production, expressed in millions of bricks, was obtained from Reference 6. The quantity was multiplied by 6.5 lb/brick. To this value was added the sum of the sewer pipes and fittings production value and the structural facing tile production value as reported in Reference 6a. The final result was the activity indicator for bricks.

The activity indicator for clay sintering was the quantity of common clay and shale used in lightweight aggregate production as reported Reference 7.

The activity indicator for concrete batching was based on the sum of the total shipments of portland cement to concrete product manufacturers and to ready-mix plants as reported in Reference 3a. The resulting sum was multiplied by 7.5.

The activity indicators for the furnace, forming, and curing processes of fiber glass production were the production of textile type and wool type glass fiber obtained from Reference 8.

The activity indicator for glass was based on the sum of the flat glass production value obtained from Reference 4 and the net packed weight of glass containers obtained from Reference 5. The resulting value was multiplied by 1.10 to account for miscellaneous glass products.

The activity indicator for calciners used in gypsum manufacturing was the quantity of calcined gypsum produced as reported in Reference 9. For dryers used in gypsum manufacturing, the activity indicator was one-half of the total quantity produced.

The activity indicators for kilns and fugitive processes used in lime manufacturing were the lime production figure obtained from Reference 2.

3.30.2.3.2   *Mining Operations* —
The activity indicator for surface coal mining was the total coal production by surface mining methods obtained from Reference 10 or from Reference 11.

For coal handling, the activity indicator was the sum of the quantity of coal cleaned and crushed and screened as reported in Reference 10. For years when these data were not reported, the value was extrapolated from latest available data based on the total coal production.

The activity indicator for coal mining thermal dryers was the quantity of coal thermally dried obtained from Reference 10. For years when these data were not available, the value was extrapolated from previous year's data, based on the change in the total coal production from Reference 10.

For coal mining, pneumatic dryers, the activity indicator was the quantity of coal processed obtained from Reference 10. For years when these data were not available, the value was extrapolated from the previous year's data based on the change in the total coal production from Reference 10.

The activity indicator for sand and gravel was the sum of the total production of sand and gravel for construction and for industrial purposes obtained from Reference 12. The total production of stone and rock crushing was obtained from Reference 13. The activity indicators for the three phosphate rock processing operations were the marketable production of phosphate rock obtained from Reference 14.

The activity indicator for clays was the total domestic clay sold or used by producers as reported in Reference 7.

The activity indicator for potash was the total potash production, expressed in potassium oxide (K_2O) equivalent, and was obtained from Reference 2.

3.30.2.3.3   *Chemical Industry* —
The activity indicator for rock pulverization for fertilizers was the sum of the phosphate rock sales of single superphosphate and triple superphosphate obtained from Reference 14.

3.30.2.4 *SO$_2$ Emissions*

The activity indicators for the three cement manufacturing processes were the total quantity of cement production as obtained from Reference 3.

The activity indicator for glass manufacturing was based on the sum of the flat glass production value obtained from Reference 4, and the net packed weight of glass containers obtained from Reference 5. The resulting value was multiplied by 1.10 to account for miscellaneous glass products.

The activity indicators for the lime kiln and fugitive processes were the lime production figure obtained from Reference 2.

3.30.2.5 VOC Emissions

The activity indicator for glass manufacturing was based on the sum of the flat glass production value obtained from Reference 4, and the net packed weight of glass containers obtained from Reference 5. The resulting value was multiplied by 1.10 to account for miscellaneous glass products.

3.30.3   Emission Factor

3.30.3.1 CO Emissions

The emission factor for asphalt roofing was the weighted average of the emission factors for controlled plants (2.85 lb/ton) and uncontrolled plants (0.22 lb/ton). The weighting factors were the fraction of plants with controls and the faction of plants without controls. The fraction of plants with controls was calculated by dividing the TSP control efficiency for the category asphalt roofing - blowing by 0.956. All other plants were assumed to operate without controls. The overall emission factor calculation is summarized in Equation 3.30-2.

$$ EF \;=\; \left[2.85 \times \left(\frac{CE_{TSP}}{0.956} \right) \right] + \left[0.22 \times \left(1 - \frac{CE_{TSP}}{0.956} \right) \right] \qquad \text{(Eq. 3.30-2)} $$

where: CE_{TSP} =   TSP control efficiency for the category asphalt roofing - blowing

The emission factor for lime manufacturing (SCC 3-05-016-04) was obtained from Reference 15a.

3.30.3.2 NO$_x$ Emissions

The emission factor for cement manufacturing (SCC 3-05-006-06) was obtained from Reference 15b.

The emission factor for glass manufacturing was the weighted average of the emission factors for three glass types as reported in Reference 15c. A list of the glass types, SCCs and weighting factors are presented in Table 3.30-1.

The emission factor for lime was the weighted average of the emission factors for the SCCs 3-05-016-xx. These emission factors and the corresponding weighting factors were obtained from Reference 16.

3.30.3.3 PM-10 and TSP Emissions

3.30.3.3.1   Mineral Products Industry —
The PM-10 and TSP emission factors for kilns used in cement manufacturing were the weighted average of the emission factors for the dry process kilns (SCC 3-05-006-06) and the wet process kilns

(SCC 3-05-007-06). These emission factors were obtained from Reference 15b for TSP and Reference 17 for PM-10. The weighting factors were the relative capacity of the wet process and of the dry process as reported in Reference 3.

The emission factors for grinders used in cement manufacturing were the weighted average of the emission factors for the dry process clinker grinder (SCC 3-05-006-17) and the wet process clinker grinder (SCC 3-05-007-17). The PM-10 and TSP emission factors were obtained from Reference 17 and Reference 15b, respectively, and were weighted by the relative capacity of the wet process and of the dry process as reported in Reference 3.

The TSP emission factors for cement manufacturing fugitive processes were obtained from Reference 18. The PM-10 emission factor was obtained from Reference 17 or Table 3.1-3 of this report.

The PM-10 and TSP emission factors for bricks was the sum of the emission factors for materials handling and for kilns. The emission factors for material handling were obtained from Reference 18 for TSP and from Reference 17 or Table 3.1-3 of this report for PM-10. The PM-10 and TSP emission factors for kilns were the weighted average of the SCCs listed in Table 3.30-2 and were obtained from Reference 17 and Reference 15d, respectively. The weighting factors were based on References 19 or 20.

The emission factors for clay sintering were the sum of the emission factors for the five processes listed in Table 3.30-3. These represent the processing of raw clay and shale combined. The raw clay sintering and finished product processing and screening emission factors for TSP were obtained from Reference 15e. The emission factors for crushing and screening and transfer and conveying were obtained from Reference 17. The storage emission factor was assumed to be 0.3 lb/ton for TSP and zero for PM-10.

The PM-10 and TSP emission factors for concrete batching (SCC 3-05-011-01) were obtained from Reference 17 and Reference 15f, respectively. The values were converted from lb/yd^3 to lbs/ton using the factor 0.5.

The emission factors for furnaces used in fiber glass manufacturing were the weighted average of the emission factors for the furnace types listed in Table 3.30-4. The emission factors for these furnace types were obtained from Reference 15g for TSP and from Reference 17 for PM-10. The weighting factors were based on the operating rates obtained from Reference 19 or 20 for these types of furnaces.

The emission factors for fiber glass forming and curing processes were the weighted average of the emission factors for three processes. The TSP emission factor for the rotary spun wool type (SCC 3-05-012-04) was obtained from Reference 21a. The TSP emission factors for the flame attenuation wool type (SCC 3-05-012-08) and the textile type (SCC 3-05-012-014) were obtained from Reference 15g. The PM-10 emission factors for the three processes were obtained from Reference 17. The weighting factors were based on the operating rates obtained from Reference 19 or 20 for these three processes.

The emission factors for glass were based on the emission factors for three types of glass: container glass, melting furnace (SCC 3-05-014-02), flat glass, melting furnace (SCC 3-05-014-03), and pressed and blown glass, melting furnace (SCC 3-05-014-04). These emission factors were obtained from

Reference 15c for TSP and From Reference 17 for PM-10. The weighted averages of these emission factors were calculated using the following weighting factors: 0.75 for container glass, 0.15 for flat glass, and 0.1 for blown and pressed glass.

The PM-10 and TSP emission factors for gypsum manufacturing dryers (SCC 3-05-015-01) and calciners (SCC 3-05-015-11) were obtained from Reference 17 and Reference 21b, respectively. For calciners, it was assumed that all calciners were continuous kettle calciners.

The emission factors for lime manufacturing kilns were the weighted average of the emission factors for two types of kilns: vertical kilns (SCC 3-05-016-03) and rotary kilns (SCC 3-05-016-04). These PM-10 and TSP emission factors were obtained from Reference 17 and Reference 15h, respectively, and were weighted using the data from Reference 22. The PM-10 and TSP emission factors for the fugitive processes were obtained from Reference 18 or Table 3.1-3 of this report.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier II category.

3.30.3.3.2   *Mining Operations* —
The PM-10 and TSP emission factors for surface mining and coal handling were obtained from Reference 18. The emission factors for thermal dryers (SCC 3-05-010-01) were obtained from Reference 15i for TSP and from Reference 17 for PM-10. The pneumatic dryers emission factors were based on engineering judgement and are presented in Table 3.1-3 of this report.

The TSP emission factor for sand and gravel was obtained from Reference 21c. The PM-10 emission factor was obtained from Reference 17 or Table 3.1-3 of this report.

The emission factors for stone and rock crushing were the weighted averages of the emission factors for the processes listed in Table 3.30-5. The PM-10 and TSP emission factors for these processes were obtained from Reference 17 and Reference 21d, respectively, and were weighted by the number of records in Reference 19 or Reference 20, except for miscellaneous operations process (SCC 3-05-020-06). Emission factors for this process were added to the weighted average of the emission factors of the other four processes.

The emission factors for phosphate rock drying or calcining processes were the weighted average of the emission factors for drying (SCC 3-05-019-01) and calcining (SCC 3-05-019-05) processes. The PM-10 and TSP emission factors were obtained from Reference 17 and Reference 15j, respectively, and were weighted by the 1974 production of phosphate rock reported in Reference 14a. It was assumed that phosphate rock production from Florida represented the drying processes and production from the western States represented the calcining process.

The emission factors for phosphate rock grinding (SCC 3-05-019-02) and material handling (SCC 3-05-019-03) were obtained from Reference 15j for TSP and from Reference 17 for PM-10.

The emission factors for clays were the weighted averages of the emission factors for three processes: drying (SCC 3-05-008-01), grinding (SCC 3-05-008-02), and storage (SCC 3-05-008-03). The PM-10 and TSP emission factors were obtained from Reference 17 and Reference 15k, respectively.

Weighting factors were 0.7 for the drying process, 1 for the grinding process and 0.5 for the storage process.

The TSP emission factor for potash was calculated by dividing actual emissions reported in Reference 16 by total production of potash, expressed in potassium oxide (K_2O) equivalent weights, obtained from Reference 7. The PM-10 emission factor was obtained from Reference 17.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier II category.

3.30.3.3.3   *Chemical Industry —*

The PM-10 and TSP emission factors for rock pulverization (SCC 3-05-019-02) were obtained from Reference 17 and Reference 22, respectively. For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier II category.

3.30.3.4 *SO$_2$ Emissions*

The emission factor for cement manufacturing was based on the uncontrolled SO_2 emissions, the total cement production, and the SO_2 control efficiency for cement kilns. The uncontrolled emissions were produced by mineral sources and by the combustion of fuels used to fire the kilns. The uncontrolled emission factors for the mineral sources and the combustion of coal, residual oil, and distillate oil are presented in Table 3.30-6. The uncontrolled emissions from mineral sources were calculated using the emission factor and the total cement production obtained from Reference 3.

The uncontrolled emissions from coal combustion were calculated using the emission factor, the coal consumed by cement plants obtained from Reference 3, and the sulfur content of the coal. The sulfur content was the average sulfur content for all coal shipped to industrial plants. The average sulfur content of coal was determined from the sulfur content by coal producing districts obtained for the category "Other industrial uses and retail dealers" in Reference 10a. This reference provided the sulfur content values reported in 1977 and it was assumed that these values remained constant during the years 1940 through 1984. In order to obtain the average sulfur content for a specific year, the sulfur content by district was weighted by the distribution of coal by district or origin for the category "Other Industrial" obtained from Reference 23 or 24.

The uncontrolled emissions from residual oil were calculated using the emission factor, the residual oil consumed by cement plants, and the sulfur content of the oil. The quantity of residual oil consumed by cement plants was assumed to be two-thirds of the total oil consumed by cement plants as reported in Reference 3. The sulfur content for residual oil was for No. 6 fuel oil obtained from Reference 25.

The uncontrolled emissions from distillate oil were calculated using the emission factor, the residual oil consumed by cement plants, and the sulfur content of the oil. The quantity of distillate oil consumed by cement plants was assumed to be one-third of the total oil consumed by cement plants as reported in Reference 3. The sulfur content for distillate oil was assumed to be 0.3 percent.

The uncontrolled emission factor for cement manufacturing was determined by dividing the total uncontrolled emissions from mineral sources and fuel combustion by the total cement production obtained from Reference 3. These calculations are summarized in Equation 3.30-3:

$$EF_{SO_2,\ controlled} = \frac{E_{SO_2,\ uncontrolled}}{P_{cement}} \times (1 - CE_{SO_2,\ klins}) \qquad \text{(Eq. 3.30-3)}$$

where: EF = emission factor
      E = emissions
      P = production
      CE = control efficiency

The SO_2 control efficiency for kilns was interpolated from the TSP control efficiency for cement kilns. The TSP control efficiency is described in section 3.30.4.2. The interpolation of the SO_2 control efficiency from the TSP control efficiency was made using the following two reference points: TSP control efficiency of 0.99 corresponded to a SO_2 control efficiency of 0.1375 and TSP control efficiency of 0.95 corresponded to a SO_2 control efficiency of 0.12.

The SO_2 emission factor for glass manufacturing was the weighted average of the emission factor for the three types of glass: container glass, furnace (SCC 3-05-014-02), flat glass, furnace (SCCS-05-014-03), and blown glass, furnace (SCC 3-05-014-04). These emission factors were obtained from Reference 15c. The weighting factors were 0.75 for container glass, 0.15 for flat glass, and 0.1 for blown glass.

The SO_2 emission factor for lime processing was calculated by dividing the total actual SO_2 emissions by the lime production rate. These values were obtained from Reference 16.

3.30.3.5 VOC Emissions

The VOC emission factor for glass manufacturing was the weighted average of the emission factor for the three types of glass: container glass, furnace (SCC 3-05-014-02), flat glass, furnace (SCCS-05-014-03), and blown glass, furnace (SCC 3-05-014-04). These emission factors were obtained from Reference 15c. The weighting factors were 0.75 for container glass, 0.15 for flat glass, and 0.1 for blown glass.

3.30.4 Control Efficiency

3.30.4.1 CO, NO_x, SO_2, and VOC Emissions

No control efficiencies were applied to the activity data to estimate CO, NO_x, SO_2, or VOC emissions from the sources included in this Tier II category.

3.30.4.2 PM-10 and TSP Emissions

3.30.4.2.1   Mineral Products Industry —
The TSP control efficiencies for all Mineral Products Industry production processes, except the fugitive processes, were derived from Reference 19 or Reference 20 using Equation 3.30-4. For any process where the emission factor was the weighted average of more specific emission factors, the control efficiency was calculated in the same manner. The more specific control efficiencies were derived using Equation 3.30-4.

$$CE \quad = \quad \left[\frac{(UE - AE)}{UE} \right] \qquad\qquad \text{(Eq. 3.30-4)}$$

where: CE = control efficiency
           UE = emissions before control
           AE = emissions after control

The TSP control efficiencies for the fugitive processes in cement manufacturing and lime manufacturing were based on engineering judgment.

The PM-10 control efficiencies for all mineral products industry production processes, except the fugitive processes, for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 26. During these years, any changes in the corresponding TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate the PM-10 emissions.

No control efficiencies were applied to the activity data to estimate PM-10 emissions from the fugitive processes in cement and lime manufacturing.

3.30.4.2.2   Mining Operations —
The TSP control efficiencies for all mining operations processes, except those described below, were derived from Reference 19 or Reference 20 using the equation given for the Mineral Products Industry processes. For any process where the emission factor was the weighted average of more specific emission factors, the control efficiency was calculated in the same manner. The more specific control efficiencies were derived using Equation 3.30-4.

For coal mining, pneumatic dryers, the TSP control efficiencies for the years 1980 through 1984 were obtained from Reference 22. No procedure for determining the control efficiencies for the years prior to 1980 is currently available.

The TSP control efficiency for clay production was the weighted average of the control efficiencies for the drying, grinding, and storage processes obtained from Reference 19 or Reference 20. The weighted average of these individual process control efficiencies was calculated in the same manner described for the clay emission factor. No procedure for determining the yearly variation in the control efficiencies is currently available.

The TSP control efficiency for potash production for the years 1981 through 1984 was assumed to be a constant value of 0.80. This value was based on engineering judgment. For the years prior to 1981, no control efficiency was applied to the activity data to estimate TSP emissions from potash production.

The PM-10 control efficiencies for coal mining thermal dryers, stone and rock crushing, phosphate rock production processes, clay production, and potash production for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 26. During these years, any changes in the corresponding TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

3.30.4.2.3   Chemical Industry —
For rock pulverization, the TSP control efficiencies for the years 1974 through 1984 were obtained from Reference 22. For the years prior to 1974, no procedure to determined the TSP control efficiencies is currently available.

The PM-10 control efficiencies for rock pulverization for the years 1975 through 1984 were equal to the 1988 PM-10 control efficiency obtained from Reference 26. For the years 1940 through 1974, no control efficiencies were use to estimate PM-10 emissions.

3.30.5   References

1. *Asphalt Usage United States & Canada*. The Asphalt Institute, College Park, MD. Annual.

2. *Chemical and Engineering News, Facts and Figures Issue*. American Chemical Society, Washington, DC. Annual.

3. *Minerals Industry Surveys*, Cement. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Monthly.
    (a) Table entitled, "Portland Cement Shipments in 19xx, by District of Origin & Type of Customer."

4. *Current Industrial Reports*, Flat Glass. Bureau of the Census, U.S. Department of Commerce, Washington, DC. Annual.

5. *Current Industrial Reports*, Glass Containers. Bureau of the Census, U.S. Department of Commerce, Washington, DC. Annual.

6. *Current Industrial Reports*, Clay Construction Products. Bureau of the Census, U.S. Department of Commerce, Washington, DC. Annual.
    (a) Table entitled, "Production and Shipments of Clay Construction Products."

7. *Minerals Yearbook*, Clays. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.

8. *Current Industrial Reports*, Fibrous Glass. Bureau of the Census, U.S. Department of Commerce, Washington, DC. Annual.

9. *Minerals Industry Surveys*, Gypsum. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Monthly.

10. *Coal Production*. DOE/EIA-0118(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
    a. Table entitled, "Shipments of Bituminous Coal and Lignite by District, Consumer, Use, Average Sulfur Content - 1977."

11. *Quarterly Coal Report: January - March*. DOE/EIA-0121(xx/1Q). Energy Information Administration, U.S. Department of Energy, Washington, DC. Quarterly.

12. *Minerals Yearbook*, Sand and Gravel. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.

13. *Minerals Industry Surveys*, Stone (Crushed and Dimension). Bureau of Mines, U.S. Department of the Interior, Washington, DC. Monthly.

14. *Minerals Yearbook*, Phosphate. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.
    a. Table entitled, "Table 2, Production of Phosphate Rock in the U.S. by Region"

15. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
    a. Volume I, Table 8.15-1
    b. Volume I, Table 8.6-1
    c. Volume I, Table 8.13-1
    d. Volume I, Table 8.3-1
    e. Volume I, Table 8.8-1
    f. Volume I, Table 8.10-1
    g. Volume I, Table 8.11-1
    h. Volume I, Table 8.15-1
    i. Volume I, Table 8.9-1
    j. Volume I, Table 8.18-1
    k. Volume I, Table 8.7-1

16. *Computer Retrieval, NE257 report, by Source Classification Code (SCC) from the National Emission Data System (NEDS)*. Unpublished computer report. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. February 9, 1980.

17. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listings for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

18. *Assessment of Fugitive Particulate Emission Factors for Industrial Processes*. EPA-450/3-78-107. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1978.

19. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

20. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

21. *Compilation of Air Pollutant Emission Factors, Third Edition, Supplements 1 through 14, AP-42*. NTIS PB-275525. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1977.
    a. Volume I, Table 8.11-1
    b. Volume I, Table 8.14-1
    c. Volume I, Section 8.19.1
    d. Volume I, Table 8.20-1

22. *Summary of Particulate and Sulfur Oxide Emission Reductions Achieved National for Selected Industrial Source Categories*. EPA-340/1-76-0086. U.S. Environmental Protection Agency, Washington, DC. November 1976.

23. *Coal Distribution: January-December 19xx*. DOE/EIA-0125(xx/4Q). U.S. Department of Energy, Washington, DC. Annual.
    a. Table entitled, "Domestic Distribution of U.S. Coal by Origin, Destination, and Consumer: January-December 19xx."

24. *Minerals Yearbook*, Coal. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.

25. *Heating Oils*. U.S. Department of Energy. Obtainable from the National Institute for Petroleum and Energy Research, ITT Research Institute, P.O. Box 2128, Bartlesville, OK. Annual.

26. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.

Table 3.30-1. NO$_x$ Emission Factor SCCs and Weighting Factors for Glass Manufacturing

SCC	Description	Weighting Factor
3-05-014-02	Container Glass: Melting Furnace	0.75
3-05-014-03	Flat Glass: Melting Furnace	0.15
3-05-014-04	Blown Glass: Melting Furnace	0.10

Table 3.30-2. PM-10 and TSP Emission Factor SCCs for Kilns Used in Brick Manufacturing

SCC	Description
3-05-003-11	Curing and firing - gas fired tunnel kiln
3-05-003-12	Curing and firing - oil fired tunnel kiln
3-05-003-13	Curing and firing - coal fired tunnel kiln
3-05-003-14	Gas fired periodic kiln
3-05-003-15	Oil fired periodic kiln
3-05-003-16	Coal fired periodic kiln

Table 3.30-3. PM-10 and TSP Emission Factor SCCs for Clay Sintering

SCC	Description
3-05-009-03	Raw clay sintering
3-05-009-04	Crushing and screening
3-05-009-05	Transfer and conveying
	Storage
3-05-009-08	Finished product processing & screening

Table 3.30-4. PM-10 and TSP Emission Factor SCCs for Fiber Glass Furnaces

SCC	Description
3-05-012-01	Glass Furnace Wool - Regenerative
3-05-012-02	Glass Furnace Wool - Recuperative
3-05-012-03	Glass Furnace Wool - Electric
3-05-012-07	Glass Furnace Wool - Unit Melter
3-01-012-11	Glass Furnace Textile - Regenerative
3-05-012-12	Glass Furnace Textile - Recuperative
3-05-012-13	Glass Furnace Textile - Unit Melter

Table 3.30-5. PM-10 and TSP Emission Factor SCCs for Stone and Rock Crushing

SCC	Description
3-05-020-01	Primary Crushing
3-05-020-02	Secondary Crushing
3-05-020-03	Tertiary Crushing
3-05-020-04	Recrushing/Screening
3-01-020-06	Miscellaneous Operations

Table 3.30-6. Uncontrolled SO_2 Emissions Factors for Cement Manufacturing

Fuel	Emission Factor	
Mineral Source	10.2	lb/ton cement produced
Coal	30.45	lb/ton coal consumed
Residual Oil	124.5	lb/1,000 gal residual oil consumed
Distillate Oil	112.35	lb/1,000 gal distillate oil consumed

3.31   SOLVENT UTILIZATION - DEGREASING: 08-01

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source category.

Tier I Category   Tier II Category

(08) SOLVENT UTILIZATION   (01) Degreasing

3.31.1   Technical Approach

The VOC emissions included in this Tier category were the emissions from the source category listed above. Emissions were estimated only for VOC from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, the activity indicator was expressed in thousand short tons and the emission factor was expressed in metric pounds/short ton.

The procedures for determining the activity indicator and emission factor were used for the years 1940, 1950, 1960, and 1970 through 1984.

3.31.2   Activity Indicator

The activity indicator for degreasing was the weighted sum of the total consumption of six solvents as reported in References 1, 2, and 3. These solvents are listed in Table 3.31-1, along with the corresponding weighting factors, expressed as percentages, and references for consumption information.

$$Activity \ = \ \sum_{i=1}^{n} \ (S_i \times U_i) \qquad\qquad \text{(Eq. 3.31-1)}$$

where: S_i =   total production/sales of solvent
            U_i =   fraction of S_i for end use as degreasing solvent (the "weighting factor" of Table 3.31-1)

3.31.3   Emission Factor

For this category, it was assumed that all of the solvents evaporated. Therefore, the VOC emission factor for degreasing was 2,000 lb/ton.

3.31.4   Control Efficiency

No control efficiencies were applied to the activity data to estimate VOC emissions from degreasing.

3.31.5   References

1.   *Petroleum Supply Annual*. DOE/EIA-0340(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.

2. *Chemical and Engineering News, Facts and Figures Issue*. American Chemical Society, Washington, DC. Annual.

3. *Synthetic Organic Chemicals, United States Production and Sales*. USITC Publication 1745. U.S. International Trade Commission, Washington, DC. Annual.

Table 3.31-1. Solvents and Weighting Factors for Degreasing

Solvent	Weighting Factor (%)	Consumption References
Special Naphtha	6.7	1
Perchloroethylene	16.3	2
Trichloroethylene	98	3
Monochlorobenzene	20	3
Cyclohexanone	1	3
Ethylene Butyl (EB) Glycol Ether	9	3

3.32   SOLVENT UTILIZATION - GRAPHIC ARTS: 08-02

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source category.

Tier I Category   Tier II Category

(08) SOLVENT UTILIZATION   (02) Graphic Arts

3.32.1   Technical Approach

The VOC emissions included in this Tier category were the emissions from the source category listed above. Emissions were estimated only for VOC from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, the activity indicator was expressed in thousand short tons and the emission factor was expressed in metric pounds/short ton.

The procedures for determining the activity indicator and emission factor were used for the years 1940, 1950, 1960, and 1970 through 1984.

3.32.2   Activity Indicator

The activity indicator for graphics arts was the weighted sum of the total consumption of four solvents, as reported in References 1, 2, and 3. These solvents are listed in Table 3.32-1, along with the corresponding weighting factors, expressed as percentages, and references for consumption information. To account for miscellaneous solvent usage, 1.8 percent of the weighted sum was added to obtain the final activity.

$$Activity = \sum_{i=1}^{n} (S_i \times U_i) \qquad \text{(Eq. 3.32-1)}$$

where: S_i =   total production/sales of solvent
U_i =   fraction of S_i for end use as degreasing solvent (the "weighting factor" of Table 3.32-1)

3.32.3   Emission Factor

For this category, it was assumed that all of the solvents evaporated. Therefore, the VOC emission factor for graphic arts was 2,000 lb/ton.

3.32.4   Control Efficiency

No control efficiencies were applied to the activity data to estimate VOC emissions from graphic arts.

3.32.5   References

1. *Petroleum Supply Annual*. DOE/EIA-0340(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.

2. *Synthetic Organic Chemicals, United States Production and Sales*. USITC Publication 1745. U.S. International Trade Commission, Washington, DC. Annual.

3. *Chemical and Engineering News, Facts and Figures Issue*. American Chemical Society, Washington, DC. Annual.

Table 3.32-1. Solvents and Weighting Factors for Graphic Arts

Solvent	Weighting Factor (%)	Consumption References
Special Naphtha	6.4	1
Ethyl Acetate	20.0	2
Ethyl Benzene	0.025	3
Ethylene Ethyl (EE) Glycol Ether	5.0	2

3.33　SOLVENT UTILIZATION - DRY CLEANING: 08-03

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source category.

Tier I Category

Tier II Category

(08) SOLVENT UTILIZATION

(03) Dry Cleaning

3.33.1　Technical Approach

The VOC emissions included in this Tier category were the emissions from the source category listed above. Emissions were estimated only for VOC from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, the activity indicator was expressed in thousand short tons and the emission factor was expressed in metric pounds/short ton.

The procedures for determining the activity indicator and emission factor were used for the years 1940, 1950, 1960, and 1970 through 1984.

3.33.2　Activity Indicator

The activity indicator for dry cleaning was the weighted sum of the total consumption of two solvents, as reported in References 1 and 2. These solvents are listed in Table 3.33-1, along with the corresponding weighting factors, expressed as percentages, and references for consumption information.

3.33.3　Emission Factor

For this category, it was assumed that all of the solvents evaporated. Therefore, the VOC emission factor for dry cleaning was 2,000 lb/ton.

3.33.4　Control Efficiency

No control efficiencies were applied to the activity data to estimate VOC emissions from dry cleaning.

3.33.5　References

1. *Petroleum Supply Annual*. DOE/EIA-0340(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.

2. *Chemical and Engineering News, Facts and Figures Issue*. American Chemical Society, Washington, DC. Annual.

Table 3.33-1. Solvents and Weighting Factors for Dry Cleaning

Solvent	Weighting Factor (%)	Consumption References
Special Naphtha	2.0	1
Perchloroethylene (93.4%)	58.9	2

3.34   SOLVENT UTILIZATION - SURFACE COATINGS: 08-04

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source category.

Tier I Category	Tier II Category	Tier II Subcategory
(08) SOLVENT UTILIZATION	(04) Surface Coatings	Architectural Coating
		Auto Refinishing
		Adhesives
		Other Solvent Use

3.34.1   Technical Approach

The VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above, except for the other solvent use subcategory. One-half of the VOC emissions for this subcategory are included in this Tier II category. Emissions were estimated only for VOC from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in thousand short tons and emission factors were expressed in metric pounds/short ton.

The procedures for determining activity indicators and emission factors were used for the years 1940, 1950, 1960, and 1970 through 1984.

3.34.2   Activity Indicator

The activity indicator for adhesives was the weighted sum of the total consumption of the three following solvents: special naphtha, methyl ethyl ketone (MEK), and methyl isobutyl ketone (MIBK). The consumption data for special naphtha was obtained from Reference 1, MEK was obtained from Reference 2, and MIBK was obtained from Reference 3. The weighting factors for the three solvents were 1, 2.1, and 0.7, respectively. The activity indicator for this source category was the sum of the weighted consumption values.

The activity indicator for architectural coating processes was based on the quantity of paint shipped obtained from Reference 4 for the paint types listed in Table 3.34-1. The quantity of paint shipped was multiplied by the corresponding solvent content given in Table 3.34-1 for each paint type. The solvent content for the architectural coatings n. s. k. type was the weighted average of the solvent content values for the other architectural coating paint types subcategories. The weighting factors were the ratio of the quantity of paint shipped for the specific paint type divided by the total quantity of paint shipped for all of the architectural coating paint types. The activity indicator for this source category was the total amount of solvent contained in the total quantity of paint shipped for all paint types.

The activity indicator for auto refinishing was the quantity of paint shipped multiplied by a solvent content value of 11.95 lb/gal. The quantity of paint shipped was obtained from Reference 4 under the

category "Automotive, other transportation and machinery refinish paints, and enamels, including primers."

The activity indicator for other solvent uses was based on the production of the solvents listed in Table 3.34-2, along with the references for these data values. The production values were converted to gallons and then to pounds using the conversion factors 43 gallons/barrel and 6.5 pounds/gallon, respectively. Each solvent production value was multiplied by the corresponding percentage consumption presented in Table 3.34-2 to obtain the solvent consumption. The values presented in Table 3.34-2 under "Solvent Consumption" were used when the referenced data was unavailable. The amount of each solvent included in this source category was the product of the solvent consumption and the corresponding percent miscellaneous solvent presented in Table 3.34-2. These products were summed and an additional 1.8 percent was added to account for miscellaneous solvents. This final result was the activity indicator for the other solvent use subcategory.

The activity indicators for the fourteen surface coating operations listed in Table 3.34-3 were based on the quantity of paint shipped obtained from Reference 4. For aircraft, railroads, and other metal products, the quantity of paint shipped was multiplied by 72.7, 27.3, and 6.5, respectively, to determine the quantity of paint included in those subcategories. The quantity of paint shipped was multiplied by the corresponding solvent content given in Table 3.34-3 for operation. The activity indicator for maintenance coatings subcategory was the sum of the activity for the interior and exterior paints as listed in Table 3.34-3.

The activity indicator for fabric coating operations was based on the textile production index obtained from Reference 1 or Reference 2. The index for 1983 and 1984 was multiplied by an adjustment factor of 3.96.

The activity indicator for plastics parts surface coating operations was based on the rubber and plastic production index obtained from Reference 1 or Reference 2. The index for 1983 and 1984 was multiplied by an adjustment factor of 0.59. For the years 1970 through 1982, the annual indicies were multiplied by an adjustment factor of 0.254. Prior to 1970, the activity was assumed to be zero for plastics parts coating surface.

The activity indicator for paper coating operations was the quantity of solvents used in the production of paper and in the production of pressure tape and labels. The amount of solvents used in the production of paper was based on the quantity of paper produced as reported in Reference 4 under the classification "paper, paperboard, film and foil finishes". This production value was multiplied by the solvent content value of 38.8 lb/gal to obtain the quantity of solvent used in the production of paper.

The quantity of solvents used in the production of pressure tape and labels was based on the consumption of the four solvents listed in Table 3.34-4. The quantity of each solvent produced was obtained from the references provided in Table 3.34-4. Each production value was multiplied by the percent consumption to determine the quantity of solvent consumed and the percent of solvent use to determine the amount of each solvent used in the production of pressure tape and labels. These values are presented in Table 3.34-4. The total quantity of solvents used was the sum of the quantities of the individual solvents.

The final activity indicator for paper coating operations was the sum of the quantity of solvent used in the production of paper and in the production of pressure tape and labels.

The activity indicator for miscellaneous surface coating processes was sum of the quantities of solvents used for the three processes listed in Table 3.34-5 and the quantity of solvent "slop". The quantities of solvents used for the three processes listed in Table 3.34-5 were calculated from the quantity of paint shipped for each process obtained from Reference 4. Each of these production values were multiplied by the corresponding percentage of solvent consumed and solvent content. The resulting solvent quantities were summed over the three processes.

To this total was added solvent "slop". This quantity was based on the difference between the following two values: (1) total quantity of specific solvents consumed by surface coating operations and (2) quantity of solvents consumed by all within the surface coating operations. The first value was based on the production level of each solvent listed in Table 3.34-6 as reported in the references indicated. Production values were converted to gallons and then to pounds using the conversion factors 43 gallons/barrel and 6.5 pounds/gallon, respectively. Each solvent production value was multiplied by the corresponding percentage consumption presented in Table 3.34-6 to obtain the solvent consumption. The values presented in Table 3.34-6 under "Solvent Consumption" were used when the referenced data was unavailable. The amount of each solvent included was the product of the solvent consumption and the corresponding percent surface coating use presented in Table 3.34-6. These products were summed and an additional 1.8 percent was added to account for miscellaneous solvents. This final result was the total quantity of solvents consumed by surface coating operations.

The second value was the sum of the quantity of solvents consumed for operations listed in Table 3.34-7. In some cases, the solvents consumed by specific processes are excluded. The solvent "slop" value was calculated by subtracting this second value from the first value, as described above.

The final activity indicator for the miscellaneous surface coating processes was the sum of the quantity of solvents consumed by the three specific processes and from solvent "slop."

3.34.3 Emission Factor

For all source categories included in this Tier II category, it was assumed that all of the solvents evaporated completely. Therefore, the VOC emission factors for all operations were 2,000 lb/ton.

Beginning in 1970, the emission factors for the following operations were scaled by annual average control efficiencies: large appliances, magnet wire, automobiles, cans, metal coils, paper, fabric, metal furniture, wood furniture, plastic parts, aircraft, machinery, other metal products, and miscellaneous processes. An adequate procedure for determining the individual control efficiencies applied to the emission factors for each opeation is currently unavailable.

3.34.4 Control Efficiency

No control efficiencies were applied to the activity data to estimate VOC emissions from surface coating operations included in this Tier II category.

3.34.5   References

1. *Petroleum Supply Annual*. DOE/EIA-0340(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.

2. *Chemical and Engineering News, Facts and Figures Issue*. American Chemical Society, Washington, DC. Annual.

3. *Synthetic Organic Chemicals, United States Production and Sales*. USITC Publication 1745. U.S. International Trade Commission, Washington, DC. Annual.

4. *Current Industrial Reports*, Paint and Allied Products. Bureau of the Census, U.S. Department of Commerce, Washington, DC. Annual.

Table 3.34-1. Determination of Activity Indicator for Architectural Coating Processes: Paint Types

Paint Type Category	Paint Type Subcategory	Solvent Content (lb/gal)
Architectural Coatings	Exterior Solvent Type	36
	Exterior Water Type	.54
	Interior Solvent Type	3.3
	Interior Water Type	.56
	Architectural lacquers	5
	Architectural coatings n.s.k.	a
Traffic marking paints		3.89
Special purpose coatings n.s.k.		5
Aerosols		5

Table 3.34-2. Determination of Activity Indicator for Miscellaneous Organic Solvent Extraction (other solvent use): Included Solvents

Compound	Solvent Production Reference	% Solvent Consumption	Solvent Consumption*	% Other Solvent Use
Special Naphthas	1	100	5461.6	5.2
n-Butanol	2	100	1269.0	0.4
Isobutanol	3	100	181.207	3.1
Butyl Acetates	3	84.2	212.4	40
Perchloroethylene	2	93.4	358.7	1
p-dichlorobenzene	3	100	90.3	90
Ethanol	2	100	549.0	35.6
Ethylene Butyl (EB) Glycol Ether	3	100	413.0	7
Diethylene Methyl (DM) Glycol Ether	3	100	46.9	30
Isopropanol	2	42	579.6	21.4
Methanol	2	95.3	7610.7	2.8
Miscellaneous**			565.9	

*   Use default values used in the event that more appropriate numbers are not available.
** Compute Miscellaneous solvents consumption as 1.8 percent of the total consumption of all other solvents

Table 3.34-3. Determination of Activity Indicators for 14 Surface Coating Operations: Solvent Contents and Reference 4 Categories

Surface Coating Operation	Reference 4 Category	Solvent Content (lb/gal)
Large Appliances	Appliance, heating equipment, & air conditioner finishes	7.35
Magnet Wire	Electrical insulating coatings	8.48
Automobiles	Automobile finishes	6.95
Cans	Container and closure finishes	4.93
Metal Coils	Sheet, strip, and coil coatings, including siding	3.15
Metal Furniture	Nonwood furniture and fixture finishes, including business equipment finishes	8.61
Wood Furniture	Wood furniture, cabinet, and fixture finishes	20.78
Flat Wood Products	Wood and composition board flat stock finishes	4.50
Large ships	Marine Paints	5.65
Machinery	Machinery and equipment finishes, including road building equipment and farm	6.63
Maintenance Coatings	Industrial new construction & maintenance paints: Interior Industrial new construction & maintenance paints: Exterior	5.66 6.30
Aircraft	Other Transportation Equipment	0.5
Railroads	Other Transportation Equipment	3.83
Other Metal Products	Other Industrial Product Finishes	19.98

Table 3.34-4. Determination of Activity Indicator for Production of Pressure Tape and Labels: Solvents Used

Solvent Category	Reference	% Solvent Consumption	% Solvent Use
Special Naphthas	2	100	10.3
Butyl Acetate	4	84.2	42.3
Methyl ethyl ketone (MEK)	3	100	15.8
Methyl isobutyl ketone (MIBK)	4	100	4.2

Table 3.34-5. Determination of the Activity Indicator for Miscellaneous Surface Coating Operations: Solvent Use in Three Processes

Process by Reference 4 category	% Solvent Consumed	Solvent Content (lb/gal)
Other Industrial Product Finishes	93.5	19.98
Product Finishes for OEM (n.s.k.)	100.0	19.98
Truck, bus, and RV	100.0	6.95

Table 3.34-6. Determination of Activity Indicator for Miscellaneous Surface Coatings Operations: Solvent Consumptions for Determination of Solvent "Slop"

Compound	Solvent Production Reference	% Solvent Consumption	Solvent Consumption*	% Surface Coating Use
Special Naphthas	2	100	5461.6	48.7
Acetone	3	89	1976.7	15.4
n-Butanol	3	100	1269.0	15.3
Isobutanol	4	100	181.207	16.7
Butyl Acetates	4	84.2	212.4	60
Cyclohexanone	4	100	1043.64	3.5
Ethyl Acetate	4	70	190.5	65
Ethanol	3	100	549.0	17.1
Ethylbenzene	3	100	8987.0	0.4
Propylene Glycol	3	100	800.0	5.7
Ethylene Methyl Glycol Ether	4	100	83.493	47
Ethylene Ethyl Glycol Ether	4	100	117.8	40
Ethylene Butyl Glycol Ether	4	100	413.0	52
Diethylene Methyl Glycol Ether	4	100	46.9	70
Diethylene Ethyl Glycol Ether	4	100	38.1	50
Diethylene Butyl Glycol Ether	4	100	9037	30
Isopropanol	3	42	579.6	21.2
Methyl Ethyl Ketone (MEK)	3	100	473.0	85.4
Methyl Isobutyl Ketone (MIBK)	4	100	426.9	71.9
Miscellaneous**			565.9	

* Use default values in the event that more appropriate numbers are not available.
** Compute Miscellaneous solvents consumption as 1.8 percent of the total consumption of all other solvents.

Table 3.34-7. Determination of Activity Indicator for Miscellaneous Surface Coatings Operations: Solvent Consumptions for All Surface Coating Operations for the Determination of Solvent "Slop"

Category	Subcategory	Excluded Sources

Surface Coating Operations	Large Appliances
	    Automobiles
	    Cans
	Metal Coils
	Paper
	Metal Furniture
	Wood Furniture
	Flat Wood Products
	Large Ships
	Aircraft
	Railroads
	Machinery
	Other Metal Products
	Miscellaneous Processes
	Maintenance Coatings
		Pressure Tapes & Labels
		
		Solvent "slop"

Miscellaneous Organic Solvent Extraction	Architectural Coatings Auto Refinishing	

3.35   SOLVENT UTILIZATION - OTHER INDUSTRIAL: 08-05

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source category.

Tier I Category	Tier II Category	Tier II Subcategory
(08) SOLVENT UTILIZATION	(05) Other Industrial	Waste Solvent Recovery Miscellaneous Organic Solvent Use Solvent Extraction Plastics Manufacturing - fabrication

3.35.1   Technical Approach

The VOC emissions included in this Tier category were the sum of the emissions from the waste solvent recovery source category multiplied by 0.78 and the emissions from the other source categories listed above. Emissions were estimated only for VOC from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in thousand short tons and emission factors were expressed in metric pounds/short ton.

The procedures for determining activity indicators and emission factors were used for the years 1940, 1950, 1960, and 1970 through 1984.

3.35.2   Activity Indicator

The activity indicator for waste solvent recovery processes was assumed to be zero.

The activity indicator for miscellaneous organic solvent uses was the weighted sum of the total consumption of eight solvents, as reported in References 1, 2, and 3. These solvents are listed in Table 3.35-1, along with the corresponding weighting factors, expressed as percentages, and references for consumption information. To account for miscellaneous solvent usage, 7.1 percent of the weighted sum was added to obtain the final activity.

The activity indicator for solvent extraction processes was the weighted sum of the total consumption of two solvents, as reported in References 1, 2, and 3. These solvents are listed in Table 3.35-2, along with the corresponding weighting factors, expressed as percentages, and references for consumption information.

The activity indicator for plastics fabrication processes was the weighted sum of the total consumption of three solvents, as reported in References 1, 2, and 3. These solvents are listed in Table 3.35-3 along with the corresponding weighting factors, expressed as percentages, and references for consumption information.

3.35.3   Emission Factor

The VOC emission factor for waste solvent recovery processes was the sum of the emission factors for the five sources presented in Table 3.35-4. These emission factors were obtained from Reference 4a.

For miscellaneous organic solvent uses, solvent extraction processes, and plastics fabrication processes it was assumed that all of the solvents evaporated completely. Therefore, the VOC emission factors for these categories were 2,000 lb/ton.

3.35.4   Control Efficiency

No control efficiencies were applied to the activity data to estimate VOC emissions from the source included in this Tier II category.

3.35.5   References

1. *Petroleum Supply Annual*. DOE/EIA-0340(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.

2. *Chemical and Engineering News, Facts and Figures Issue*. American Chemical Society, Washington, DC. Annual.

3. *Synthetic Organic Chemicals, United States Production and Sales*. USITC Publication 1745. U.S. International Trade Commission, Washington, DC. Annual.

4. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
    a.   Volume I, Table 4.7-1

Table 3.35-1. Determination of Activity Indicator for Miscellaneous Organic Solvent Uses: Solvents, Weighting Factors, and References

Solvent	Weighting Factor (%)	Consumption References
Special Naphtha	1	1
Acetone (89.0%)	0.5	2 or 3
O-Dichloro-benzene	25	2 or 3
Ethanol	5.8	2
Ethylbenzene	0.075	2
Ethylene Ethyl (EE) Glycol Ether	12	3
Ethylene Butyl (EB) Glycol Ether	12	3
Methanol (95.3%)	4.7	2

Table 3.35-2. Determination of Activity Indicator for Solvent Extraction Processes: Solvents, Weighting Factors, and References

Solvent	Weighting Factor (%)	Consumption References
Methyl Ethyl Ketone (MEK)	12.5	2
Methyl Isobutyl Ketone (MIBK)	8.9	3

Table 3.35-3. Determination of Activity Indicator for Plastics Fabrication Processes: Solvents, Weighting Factors, and References

Solvent	Weighting Factor (%)	Consumption References
Special Naphtha	6.5	1
Ethyl Acetate	12	3
Ethylbenzene	0.25	2

Table 3.35-4. VOC Emission Factor SCCs for Waste Solvent Recovery Processes

SCC	Description
4-90-002-01	Storage Tank Vent
4-90-002-02	Condenser Vent
4-90-002-03	Incinerator Stack
4-90-002-04	Solvent Spillage
4-90-002-05	Solvent Loading

3.36   SOLVENT UTILIZATION - NONINDUSTRIAL: 08-06

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source category.

Tier I Category	Tier II Category	Tier II Subcategory
(08) SOLVENT UTILIZATION	(06) Nonindustrial	Fabric Scouring Cutback Asphalt Paving Pesticides Other Solvent Use

3.36.1   Technical Approach

The VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above, except for the other solvent use category. One-half of the VOC emissions for this source category are included in this Tier II category. Emissions were estimated only for VOC from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in thousand short tons and emission factors were expressed in metric pounds/short ton.

The procedures for determining activity indicators and emission factors were used for the years 1940, 1950, 1960, and 1970 through 1984.

3.36.2   Activity Indicator

The activity indicator for fabric scouring was the consumption of perchloroethylene, obtained from Reference 1, multiplied by 0.062.

The activity indicator for cutback asphalt paving were based on the total quantity of cutback asphalt obtained from Reference 2. For years since 1980, production figures for cutback paving asphalts reported in Reference 3 were used to update the 1980 emissions. It was assumed that the 1980 emissions were proportional to changes in cutback paving asphalt production.

The activity indicator for pesticides was the weighted sum of the total consumption of six solvents, as reported in References 4 and 5. These solvents are listed in Table 3.36-1, along with the corresponding weighting factors, expressed as percentages, and references for consumption information.

The activity indicator for other solvent uses was based on the consumption of eleven solvents, as reported in References 4 and 5. These solvents are listed in Table 3.36-2, along with the corresponding references for the consumption information. Consumption value for each solvent was converted to million pounds by using the following conversion factors: 42 gallons/barrel and 6.5 pounds/gallon. The consumption data for each solvent was multiplied by the general consumption weighting factor and by the miscellaneous solvent use weighting factor in order to obtain the consumption of each solvent included within this category. Weighted solvent consumptions were summed and an additional 1.8 percent was added to account for miscellaneous solvent use.

3.36.3   Emission Factor

For all sources included in this Tier II category, it was assumed that solvents evaporated completely. Therefore, the VOC emission factors for fabric scouring, cutback asphalt paving, pesticides, and other solvent uses.

3.36.4   Control Efficiency

No control efficiencies were applied to the activity data to estimate VOC emissions from the source included in this Tier II category.

3.36.5   References

1.   *Chemical and Engineering News, Facts and Figures Issue*. American Chemical Society, Washington, DC. Annual.

2.   *Energy Data Reports, Sales of Asphalt in 1980*. U.S. Department of Energy, Washington, DC. June 1981.

3.   *Asphalt Usage United States & Canada*. The Asphalt Institute, College Park, MD. Annual.

4.   *Petroleum Supply Annual*. DOE/EIA-0340(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.

5.   *Synthetic Organic Chemicals, United States Production and Sales*. USITC Publication 1745. U.S. International Trade Commission, Washington, DC. Annual.

**Table 3.36-1. Determination of Activity Indicator for
Pesticides: Solvents, Weighting Factors, and References**

Solvent	Weighting Factor (%)	Consumption References
Special Naphthas	3.3	4
Isobutanol	3.2	5
m-chlorobenzene	30.0	5
Ethyl Benzene	0.19	1
Ethylene Butyl (EB) Glycol	13.0	5
Ether	2.3	5
Methyl Isobutyl Ketone (MIBK)		

**Table 3.36-2. Determination of Activity Indicator for Other Solvent Uses of
Miscellaneous Organic Solvents: Solvents, Weighting Factors, and References**

Solvent	General Consumption Weighting Factor (%)	Miscellaneous Consumption Weighting Factor (%)	Consumption References
Special Naphthas	100	5.2	4
n-Butanol	100	0.4	1
Isobutanol	100	3.1	5
Butyl Acetates	84.2	40.0	5
Perchloroethylene	93.4	1.0	1
p-dichlorobenzene	100	90.0	5
Ethanol	100	35.6	1
Ethylene Butyl (EB) Glycol Ether	100	7.0	5
Diethylene Methyl (DM) Glyco Ether	100	30.0	5
Isopropanol	42	21.4	1
Methanol	95.3	2.8	1

3.37   STORAGE AND TRANSPORT - BULK TERMINALS AND PLANTS: 09-01

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source category.

Tier I Category   Tier II Category

(09) STORAGE AND   (01) Bulk Terminals and Plants
        TRANSPORT

3.37.1   Technical Approach

The VOC emissions included in this Tier category were the emissions from the source categories listed above. Emissions were estimated only for VOC from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in million barrels and emission factors were expressed in metric pounds/thousand barrels. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984.

3.37.2   Activity Indicator

The activity indicators for bulk gasoline terminal transfer and storage were the production of finished motor gasoline obtained from Reference 1a. This quantity was reported under the heading "Disposition: Products Supplied."

The activity indicators for bulk gasoline plant transfer and storage were 30 percent of the production of finished motor gasoline obtained from Reference 1a. This quantity was reported under the heading "Disposition: Products Supplied."

3.37.3   Emission Factor

For the years 1970 through 1984, the emission factors for all source categories included in this Tier II category were based on 1980 emissions data obtained from Reference 2 and 1979 production data from Reference 1. A more detailed procedure is currently unavailable.

For the years 1960, 1950, and 1940, the emission factors for all source categories, except for transport at bulk gasoline terminals, steadily increased from the 1970 value. No procedure for determining these emission factors is currently available.

3.37.4   Control Efficiency

No control efficiencies were applied to the activity data to estimate VOC emissions from transfer and storage at gasoline bulk plants. For the years 1974 through 1984, control efficiencies were applied to

the activity data to estimate emissions from transfer and storage at gasoline bulk terminals. No procedure for determining these control efficiencies is currently available.

3.37.5   References

1. *Petroleum Supply Annual*. DOE/EIA-0340(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
   a.   Table entitled, "Supply and Disposition of Crude Oil and Petroleum Products."

2. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS).* Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. June 12, 1980.

**3.38   STORAGE AND TRANSPORT - PETROLEUM AND PETROLEUM PRODUCT
        STORAGE: 09-02**

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the
following source category.

Tier I Category	Tier II Category	Tier II Subcategory
(09) STORAGE AND TRANSPORT	(02) Petroleum and Petroleum Product Storage	Gasoline Storage at Refineries Crude Oil Storage - oil field storage and refinery storage Other Products - jet naphtha storage, jet naphtha transfer, kerosene storage, and distillate oil storage

3.38.1   Technical Approach

The VOC emissions included in this Tier category were the emissions from the source categories
listed above. Emissions were estimated only for VOC from an activity indicator, emission factor, and
control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity
indicators were expressed in million barrels and emission factors were expressed in metric
pounds/thousand barrels. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control
efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984.

3.38.2   Activity Indicator

The activity indicator for gasoline storage at refineries was the production of finished gasoline
obtained from Reference 1a.

The activity indicators for crude oil field storage was the total U.S. field production including lease
condensate obtained from Reference 1b.

The activity indicators for crude refinery storage was the crude oil input to refineries obtained from
Reference 1c.

The activity indicators for both jet naphtha transfer and jet naphtha storage were the production of
naphtha-type jet fuel obtained from Reference 1c. The activity indicators for kerosene storage was the
sum of kerosene-type jet fuel and kerosene obtained from Reference 1c. The activity indicator for
distillate oil storage was the quantity of distillate fuel oil obtained from Reference 1c. These quantities
were reported under the heading "Disposition: Products Supplied."

3.38.3   Emission Factor

For the years 1970 through 1984, the emission factors for crude oil storage at refineries, gasoline storage at refineries, jet naphtha storage, jet naphtha transfer, kerosene storage, and distillate oil storage were based on 1980 emissions data from Reference 2 and 1979 petroleum production data from Reference 1. A more detailed procedure is currently unavailable.

For the years 1960, 1950, and 1940, emission factors for crude oil storage at refineries and gasoline storage at refineries steadily increased from the 1970 value. The emission factors of the other sources listed above remained constant at the 1970 value. No procedure for determining these changing emission factors is currently available.

For the years 1970 through 1984, the emission factor for crude oil storage at oil fields was based on the typical losses from storage tank types. The losses were calculated using equations and typical values from Reference 3. The losses from the different tank types were weighted based on data from Reference 2. A more detailed procedure is currently unavailable. The emissions factors for the years 1960, 1950, and 1940 increased steadily over the 1970 value. No procedure for determining these emission factors is currently available.

3.38.4   Control Efficiency

No control efficiencies were applied to the activity data to estimate VOC emissions from the source included in this Tier II category, except for gasoline storage at refineries. For the years 1974 through 1984, control efficiencies were applied to the activity data to estimate emissions from gasoline storage at refineries. No procedure is currently available to determine these control efficiencies.

3.38.5   References

1. *Petroleum Supply Annual*. DOE/EIA-0340(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
   a.   Table entitled, "Refinery Production of Petroleum Products by PAD District."
   b.   Table 1
   c.   Table entitled, "Supply and Disposition of Crude Oil and Petroleum Products."

2. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. June 12, 1980.

3. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.

3.39   STORAGE AND TRANSPORT - PETROLEUM AND PETROLEUM PRODUCT TRANSPORT: 09-03

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source category.

Tier I Category	Tier II Category	Tier II Subcategory
(09) STORAGE AND TRANSPORT	(03) Petroleum and Petroleum Product Transport	Refinery Product Loading - gasoline tank car and tanker and barge Crude Oil Loading - tank car/ truck, ship and barge, and tanker ballasting

3.39.1   Technical Approach

The VOC emissions included in this Tier category were the emissions from the source categories listed above. Emissions were estimated only for VOC from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in million barrels and emission factors were expressed in metric pounds/thousand barrels. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984.

3.39.2   Activity Indicator

The activity indicator for refinery product loading of tankers and barges was the total movement of finished motor gasoline between the following PAD districts: from PAD III to PAD I, from PAD II to PAD II, from PAD III to PAD V, and from PAD V to PAD III. This information was obtained from Reference 1a.

The activity indicator for refinery product loading of gasoline tank cars was assumed to be 3.35 percent of the total U.S. production of finished gasoline obtained from Reference 1b.

The activity indicator for crude oil loading of tank cars/trucks was the total receipts of domestic tank cars and domestic trucks. The activity indicator for ship and barge loading was the total receipts of domestic crude oil on tankers and barges. The activity indicator for the tanker ballasting was one-half of the total receipts of domestic crude oil on tankers and barges added to the total receipts of foreign crude oil on tankers and barges. Information required for these activity indicators was obtained from Reference 1c.

3.39.3   Emission Factor

The emission factors for all sources included in this Tier II category were based on 1980 emissions data from Reference 2 and 1979 petroleum production data from Reference 1. The emission factors were constant for all years. More detailed procedures are currently unavailable.

3.39.4   Control Efficiency

No control efficiencies were applied to the activity data to estimate VOC emissions from the source included in this Tier II category, except for gasoline transfer at refineries. For the years 1974 through 1984, control efficiencies were applied to activity to estimate emissions from gasoline transfer at refineries. No procedure for determining these control efficiencies is currently available.

3.39.5   References

1. *Petroleum Supply Annual*. DOE/EIA-0340(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
    a. Table entitled, "Movements of Crude Oil and Petroleum by Tanker and Barge Between PAD District."
    b. Table entitled, "Refinery Production of Petroleum Products by PAD District."
    c. Table entitled, "Refinery Receipts of Crude Oil by Method of Transportation."

2. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. June 12, 1980.

3.40 STORAGE AND TRANSPORT - SERVICE STATIONS: STAGE I: 09-04

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source category.

Tier I Category	Tier II Category	Tier II Subcategory
(09) STORAGE AND TRANSPORT	(04) Service Stations: Stage I	Gasoline Service Stations - loading or stage I

3.40.1 Technical Approach

The VOC emissions included in this Tier category were the emissions from the source categories listed above. Emissions were estimated only for VOC from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, the activity indicator was expressed in million barrels and the emission factor was expressed in metric pounds/thousand barrels. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984.

3.40.2 Activity Indicator

The activity indicator for gasoline service station loading or stage I was the production of finished motor gasoline obtained from Reference 1a. This quantity was reported under the heading "Disposition: Products Supplied."

3.40.3 Emission Factor

The emission factor for gasoline service station loading for the years 1970 through 1984 was based on the 1980 emission data from Reference 2 and 1979 petroleum production data from Reference 1. A more detailed procedure is currently unavailable.

For the years 1960, 1950, and 1940, the emission factors steadily increased from the 1970 value. No procedure for determining these emission factors is currently available.

3.40.4 Control Efficiency

For the years 1978 through 1984, control efficiencies were applied to the activity to estimate VOC emissions from gasoline station loading. No procedure for determining these control efficiencies is currently available.

3.40.5   References

1. *Petroleum Supply Annual*. DOE/EIA-0340(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
   a.   Table entitled, "Supply and Disposition of Crude Oil and Petroleum Products."

2. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. June 12, 1980.

3.41   STORAGE AND TRANSPORT - SERVICE STATIONS: STAGE II: 09-05

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source category.

Tier I Category	Tier II Category	Tier II Subcategory
(09) STORAGE AND TRANSPORT	(05) Service Stations: Stage II	Gasoline Service Stations - loading or stage II

3.41.1   Technical Approach

The VOC emissions included in this Tier category were the emissions from the source categories listed above. Emissions were estimated only for VOC from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in million barrels and emission factors were expressed in metric pounds/thousand barrels. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984.

3.41.2   Activity Indicator

The activity indicator for gasoline service station unloading or stage II was the production of finished motor gasoline obtained from Reference 1a. This quantity was reported under the heading "Disposition: Products Supplied."

3.41.3   Emission Factor

The emission factor for gasoline service station unloading was based on 1980 emissions data from Reference 2 and 1979 petroleum production data from Reference 1. This value was used for all years. More detailed procedure is currently unavailable.

3.41.4   Control Efficiency

For the years 1979 through 1984, control efficiencies were applied to the activity data to estimate VOC emissions from gasoline service station unloading. No procedure for determining these control efficiencies is currently available.

3.41.5   References

1. *Petroleum Supply Annual*. DOE/EIA-0340(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
    a.   Table entitled, "Supply and Disposition of Crude Oil and Petroleum Products."

2. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. June 12, 1980.

3.42   STORAGE AND TRANSPORT - ORGANIC CHEMICAL STORAGE: 09-07

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source category.

Tier I Category	Tier II Category	Tier II Subcategory
(09) STORAGE AND TRANSPORT	(07) Organic Chemical Storage	Waste Solvent Recovery Waste Disposal

3.42.1   Technical Approach

The VOC emissions included in this Tier category were the sum of the emissions from the waste solvent recovery source category multiplied by 0.22 and the emissions from the other source categories listed above. Emissions were estimated only for VOC from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, the activity indicators were expressed in thousand short tons and the emission factors were expressed in metric pounds/short tons.

The procedures for determining activity indicators and emission factors were used for the years 1940, 1950, 1960, and 1970 through 1984.

3.42.2   Activity Indicator

The activity indicator for waste solvent recovery was assumed to be zero.

The activity indicator for waste disposal in petrochemical manufacturing was based on the industrial organic chemical production index obtained from Reference 1.

3.42.3   Emission Factor

The VOC emission factor for waste solvent recovery was the sum of the emission factors for the five source listed in Table 3.42-1. Emission factors for these sources were obtained from Reference 2a.

The emission factor for waste disposal in petrochemical manufacturing was obtained from Reference 3.

3.42.4   Control Efficiency

No control efficiencies were applied to the activity data to estimate VOC emissions from the source included in this Tier II category.

3.42.5   References

1. *Chemical and Engineering News, Facts and Figures Issue*. American Chemical Society, Washington, DC. Annual.

2. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
    a.   Volume I, Table 4.7-1

3. *Organic Chemical Manufacturing, Volume 1: Program Report*. EPA-450/3-80-023. U.S. Environmental Protection Agency, Research Triangle Park, NC. December 1980.

Table 3.42-1. VOC Emission Factor SCCs for Waste Solvent Recovery

SCC	Description
4-90-002-01	Storage Tank Vent
4-90-002-02	Condenser Vent
4-90-002-03	Incinerator Stack
4-90-002-04	Solvent Spillage
4-90-002-04	Solvent Loading

3.43   WASTE DISPOSAL AND RECYCLING - INCINERATION: 10-01

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source category.

Tier I Category	Tier II Category	Tier II Subcategory
(10) WASTE DISPOSAL AND RECYCLING	(01) Incineration	Municipal Residential Commercial/Institutional Conical Woodwaste

3.43.1   Technical Approach

The CO, NO_x, PM-10, TSP, SO_2, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in million short tons and emission factors were expressed in metric pounds/short ton. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to Equation 3.43-1.

$$PM\text{-}10\ Emissions_{year}\ =\ PM\text{-}10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}} \qquad \text{(Eq. 3.43-1)}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.43.2   Activity Indicator

The activity indicator for municipal incineration was the sum of the operating rates for the SCCs 5-01-001-01 and 5-01-001-02 obtained from Reference 1 or 2.

The activity indicator for residential incineration was the operating rate for residential on-site incineration obtained from Reference 3.

The activity indicator for commercial/industrial incineration was based on the sum of the operating rates provided in Reference 1 or 2 for the following SCCs: 5-02-001-01, 5-02-001-02, 5-03-001-01, and 5-03-001-02. The total operating rates for these SCCs were calculated for the year under study and for the previous year. The activity indicator for the year under study was determined by scaling the activity indicator for the previous year with the rate of the total operating rates for the year under study and the previous year. Equation 3.43-2 summarizes this calculation.

$$AI_i = AI_{i-1} \times \left(\frac{OR_i}{OR_{i-1}} \right)$$
(Eq. 3.43-2)

where: i = year
        AI = activity indicator
        OR = total operating rates

The activity indicator for conical woodwaste incineration was the sum of the operating rates for the SCCs 5-02-001-05 and 5-03-001-05 obtained from Reference 1 or 2.

3.43.3   Emission Factor

The emission factors for all pollutants except PM-10 and VOC for municipal incineration were obtained from Reference 4a for the starved air category. The TSP emission factor represented controlled emissions and, therefore, a separate TSP control efficiency was not used for this category. The PM-10 emission factor was obtained from Reference 5. The source of the VOC emission factor for this source is currently unavailable.

The emission factors for the residential category were the weighted average of the emission factors for the two types of domestic single chamber incinerators. These emission factors were obtained from Reference 4b for all pollutants except PM-10. The PM-10 emission factors for these incinerators were obtained from Reference 5 or Table 3.1-3 of this report. The weighting factor for the incinerator without a primary burner was 0.9 and with a primary burner was 0.1.

The emission factor for the commercial/institutional category were the weighted average of the emission factors for the two combustor types: multiple chamber (SCC 5-02-001-01) and single chamber (SCC 5-02-001-02). These emission factors for all pollutants except PM-10 were obtained from Reference 4c. The PM-10 emission factors were obtained from Reference 5. The weighting factor for the multiple chamber combustor was 0.85 and for the single chamber burner was 0.15.

The emission factors for all pollutants except PM-10 for the conical woodwaste category (SCC 5-02-001-05) were obtained from Reference 4d. The PM-10 emission factor was obtained from Reference 5.

3.43.4   Control Efficiency

No control efficiencies were applied to the activity data to estimate CO, NO_x, SO_2, TSP, or VOC emissions from solid waste disposal processes.

The PM-10 control efficiencies for incineration of municipal and commercial and industrial waste for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 6. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

3.43.5   References

1. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

2. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

3. *Standard Computer Retrievals, NE260 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

4. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
    a. Volume I, Table 2.1-1
    b. Volume I, Table 2.1-4
    c. Volume I, Table 2.1-3
    d. Volume I, Table 2.3-1

5. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listings for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

6. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.

3.44   WASTE DISPOSAL AND RECYCLING - OPEN BURNING: 10-02

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source category.

Tier I Category	Tier II Category	Tier II Subcategory
(10) WASTE DISPOSAL AND RECYCLING	(02) Open Burning	Dumps On-site

3.44.1   Technical Approach

The CO, NO$_x$, PM-10, TSP, SO$_2$, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in million short tons and emission factors were expressed in metric pounds/short ton.

The procedures for determining activity indicators and emission factors were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\text{-}10\ Emissions_{year}\ =\ PM\text{-}10\ Emissions_{1975}\ \times\ \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}} \qquad \text{(Eq. 3.44-1)}$$

This calculation was used in place of estimating emissions based on activity indicators and emission factors.

3.44.2   Activity Indicator

The activity indicator for open burning dumps was the sum of the operating rates for open burning dumps (SCCs 5-01-002-01 and 5-01-002-02) obtained from Reference 1 or 2.

The activity indicator for on-site open burning was the sum of the operating rate for open burning (SCCs 5-02-002-01, 5-02-002-02, 5-03-002-01, 5-03-002-02, 5-03-002-03, and 5-03-002-04) obtained from Reference 3.

3.44.3   Emission Factor

The emission factors for all pollutants except PM-10 for both open burning sources were obtained from Reference 4a. The PM-10 emission factors were obtained from Reference 5.

3.44.4   Control Efficiency

No control efficiencies were applied to the activity data to estimate emissions from solid waste disposal processes.

3.44.5   References

1. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

2. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

3. *Standard Computer Retrievals, NE260 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

4. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
    a.   Volume I, Table 2.4-1

5. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listing for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

3.45   WASTE DISPOSAL AND RECYCLING - OTHER: 10-07

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source category.

Tier I Category	Tier II Category	Tier II Subcategory
(10) WASTE DISPOSAL AND RECYCLING	(07) Other	Waste Disposal of Petrochemicals

3.45.1   Technical Approach

The VOC emissions included in this Tier category were the emissions from the source category listed above. Emissions were estimated only for VOC from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, the activity indicator was expressed in thousand short tons and the emission factor was expressed in metric pounds/short tons.

The procedures for determining activity indicator and emission factor were used for the years 1940, 1950, 1960, and 1970 through 1984.

3.45.2   Activity Indicator

The activity indicators for the disposal of waste from the manufactur of petrochemicals was based on the industrial organic chemical production index obtained from Reference 1.

3.45.3   Emission Factor

The VOC emission factor for this source category was obtained from Reference 2.

3.45.4   Control Efficiency

No control efficiencies were applied to the activity data to estimate VOC emissions from solid waste disposal processes.

3.45.5   References

1.   *Chemical and Engineering News, Facts and Figures Issue*. American Chemical Society, Washington, DC. Annual.

2.   *Organic Chemical Manufacturing, Volume 1: Program Report*. EPA-450/3-80-023. U.S. Environmental Protection Agency, Research Triangle Park, NC. December 1980.

3.46   ON-ROAD VEHICLES: 11

The emissions for all Tier II categories under this Tier I category were determined by the 1940-1984 Methodology for the following source category:

Tier I Category   Tier II Category

(11) ON-ROAD VEHICLES   (01) Light-duty Gasoline
                                                          Vehicles (LDGV) and
                                                          Motorcycles (MC)
                                                 (02) Light-duty Gasoline
                                                          Trucks (LDGT)
                                                 (03) Heavy-duty Gasoline
                                                          Vehicles (HDGV)
                                                 (04) Diesels

3.46.1   Technical Approach

On-road vehicle emissions for the years 1940, 1950, and 1960 were estimated at the national level for CO, NO_x, and VOC (modeled as nonmethane organic gases (NMOG)). The emissions were based on vehicles miles traveled (VMT) and mobile emission factors. The emissions were calculated for eight vehicle types [LDGV, MC, LDGT-1, LDGT-2, HDGV, heavy-duty diesel vehicles (HDDV), light-duty diesel trucks (LDDT), and light-duty diesel vehicles (LDDV)] and three road types (limited access roads, urban roads, and rural roads). The national annual SO_2, TSP, and PM-10 emissions were calculated using total VMT and emission factors.

3.46.2   Activity Indicator

The activity indicator was national VMT data for each vehicle type and road type as shown in Tables 3.46-1, 3.46-2, and 3.46-3 for 1940, 1950, and 1960, respectively. These data were developed from VMT data from Reference 1 and redistributed by vehicle type and road type using information from References 2 and 3.

Difficulty arises in determining the VMT due to the fact that the EPA vehicle classifications do not correspond directly to the classifications reported in Highway Statistics, Reference 1. As a result, the reported VMTs will need to be reclassified.

The following procedures were performed except for those instances where the data was not available then assumptions were made. These assumptions were not documented and therefore cannot be included in this report.

Step 1.

Tables VM-1 and VM-2 from the latest version of Highway Statistics, Reference 1 were obtained.

Step 2.

The total national VMTs for each EPA vehicle classification were calculated as follows:

For LDDV: The latest issue of the Market Data Book, Reference 3 was obtained. From this document, the total number of original sales of diesel passenger cars for the latest model year were extracted. The estimate of the number of LDDV surviving by calendar year since 1968 was calculated as follows:

$$\begin{matrix} LDDV\,surviving \\ by\,model\,year \end{matrix} = \begin{bmatrix} passenger\,car\,survival \\ rate\,by\,age \end{bmatrix} \times \begin{bmatrix} LDDV\,original \\ sales\,by\,model\,year \end{bmatrix} \qquad \text{(Eq. 3.46-1)}$$

Where the passenger car survival rates were found in Reference 2.

For LDGV: The total VMT for LDDV was subtracted from the total passenger car VMT reported in VM-1 to get the total number of VMT for LDGV.

For LDGT1, LDGT2, and HDGV: The number of truck sales by weight category was obtained from Reference 2. For example, in the 1986 edition these values were in the two tables entitled "Retail Sales of New Trucks by Gross Vehicle Weight and Body Type" and "Total Retail Sales of New Trucks in the United States." The U.S. factory sales of domestic trucks was obtained from Reference 2. It was assumed that all imports are in the 0 - 6,000-lb class. Equations 3.42-2 through 3.46-6 summarizes how the sales of each truck class were calculated.

$$Sales\ LDGT1\ =\ RS_{0\,to\,6K}\ +\ I-\ DFS_{0\,to\,6K} \qquad \text{(Eq. 3.46-2)}$$

$$Sales\,LDGT2 = RS_{6\,to\,10K} - VCC - M - 0.05 \times CP - DFS_{6\,to\,10K} - DT_{10\,to\,14K} \qquad \text{(Eq. 3.46-3)}$$

$$Sales\,HDGT = VCC + M + 0.05 \times CP - HDDT + RS_{>10K} \qquad \text{(Eq. 3.46-4)}$$

$$Sales\,LDDT = DFS_{0\,to\,6k} +\ 0.1 \times DFS_{6\,to\,10k} \qquad \text{(Eq. 3.46-5)}$$

$$Sales\,HDDT = 0.9 \times DFS_{6\,to\,10k} + DFS_{10\,to\,14k} + DFS_{14\,to\,16k}$$
$$+ DFS_{16\,to\,19.5k} + DFS_{19.5\,to\,26k} + DFS_{26\,to\,33k} + DFS_{733k} \quad \text{(Eq. 3.46-6)}$$

where:
RS	=	retail sales of domestic trucks
I	=	retail sales of import trucks
DFS	=	factory sales of diesel trucks
VCC	=	retail sales of van cutaway chassis
M	=	retail sales of multistops
CP	=	retail sales of conventional pickups
HDDT	=	sales HDDT, also calculated above.

Step 3.

    This next step converted the original sales of trucks into the number of trucks actually operating. For each of the past 20 years, the ratio of the total number of trucks operating to the total number of sales was calculated using the table entitled "Trucks in Operation by Model Year" from Reference 2. The number of trucks in each category operating by model year was then calculated by multiplying the ratio for the given year by the estimated retail sales for the year of interest. Equation 3.46-7 was used.

$$LDGT1 = RS_{iLDGT1} \times \frac{TT_i}{TRS_i} \quad \text{(Eq. 3.46-7)}$$

where:
LDGT1	=	number of trucks in this category
RS_{ixxx}	=	retail sales for year i and truck type xxx
TT_i	=	total number of trucks operating for year i from Reference 2
TRS_i	=	total retail sales of trucks for year i.

The same procedure was repeated for each vehicle classification.

    Note: The MVMA report, Reference 2, may only give operating and sales statistics for the past 16 years. Yet, this must be completed for the past 20 years. This can be done by estimating the number of trucks in operation for the i-16th through i-19th years as shown in Equation 3.46-8.

$$\begin{matrix} Model\,yr\,i\text{-}16 \\ trucks\,in\,operation = \\ in\,calendar\,year\,i \end{matrix} \left[1 - \left(\begin{matrix} Model\,yr\,i\text{-}14 \\ trucks\,in\,operation \end{matrix} \frac{\begin{matrix} Model\,yr\,i\text{-}15 \\ trucks\,in\,operation \end{matrix}}{\begin{matrix} Model\,yr\,i\text{-}14 \\ trucks\,in\,operation \end{matrix}} \right) \right] \times \begin{matrix} Model\,yr\,i\text{-}15 \\ trucks\,in\,operation \end{matrix} \quad \text{(Eq. 3.46-8)}$$

Step 4.

The total number of VMT by vehicle class is calculated next. This was done by multiplying the number of trucks for each year by the corresponding VMT value. The exception to this procedure was the calculation for HDDT, in which the average of all factory sales data available in each weight class was used to weight the VMT subtotals. Equation 3.46-9 was used.

$$HDDT = \frac{\begin{array}{c} VMT_{HDD-2B} \times 0.9 \times avg[DFS_{HDD-2B}] + \ VMT_{LHDD} \times \ avg[DFS_{LHDD}] \\ + \ VMT_{MHDD} \times \ avg[DFS_{MHDD}] + VMT_{HHDD} \times avg[DFS_{HHDD}] \end{array}}{0.9 \times avg[DFS_{HDD-2B}] + avg[DFS_{LHDD}] + avg[DFS_{MHDD}] + avg[DFS_{HHDD}]} \qquad \text{(Eq. 3.46-9)}$$

where: VMT   =   vehicle miles traveled
        avg (DFS) =   "U.S. factory sales of diesel trucks" data available from AAMA, Reference 2, for respective weight class weighted by information on trucks in use by age, available from AAMA, Reference 2.

The totals were then sum on each vehicle type. The estimates were then normalized to the total number of VMT reported in VM-1 for all trucks and buses. This was done by multiplying each of the total VMTs for each truck category by the ratio of the total VMT reported in VM-1 to the total VMT estimated above.

Step 5.

Next the fraction of the VMT reported for "Other Urban" in Table VM-1 for 55 MPH and 19.6 MPH was calculated using Equations 3.46-10 and 3.46-11.

$$OU_{55MPH} \ = \ \frac{Other\,Freeways \ + \ Other\,Principal\,Arterial}{Other\,Urban} \qquad \text{(Eq. 3.46-10)}$$

$$OU_{19.6MPH} \ = \ \frac{Minor\,Arterial \ + \ Collector \ + \ Local}{Other\,Urban} \qquad \text{(Eq. 3.46-11)}$$

where: OU =   Other Urban VMT obtained from Table VM-1.

All other values obtained from Table VM-2.

Step 6.

The total VMTs by vehicle type were then divided into 3 road speed categories: 55 MPH, 45 MPH, and 19.6 MPH. For each vehicle type, the VMTs were added together for all road speed categories and

the fraction of total VMT represented by each speed category was computed using Equations 3.46-12 through 3.46-14.

$$raction_{55MPH,i} = InterstateRural_i + OtherRural_i + InterstateUrban_i + OU_{55MPH} \times OtherUrba \qquad \text{(Eq. 3.46-12)}$$

$$Fraction_{45MPH,i} = \frac{OtherRural_i}{TotalRuralandUrban_i} \qquad \text{(Eq. 3.46-13)}$$

$$Fraction_{19.6\ MPH} = \frac{OU_{19.6\ MPH} \times OtherUrban_i}{TotalRuralandUrban_i} \qquad \text{(Eq. 3.46-14)}$$

where: i =   vehicle type (personal passenger vehicles, 2-axle 4-tire single unit trucks, combination trucks)
OU_{55MPH} =   value calculated in Equation 3.46-10
$OU_{19.6MPH}$ =   value calculated in Equation 3.46-11

All other values taken from Table VM-1.

The fractions computed for the VMTs for "Personal Passenger Vehicles" were used to represent the distribution of VMT for LDGV, LDDV, and MC by road speed categories. The fractions were then multiplied by the total VMT for those categories to obtain VMT for each road speed category for each vehicle class. The fraction computed for "2-axle, 4-tire single-unit trucks" was used to distribute total VMT for LDGT1, LDGT2, and LDDT. The fractions computed for "combinations" were used to distribute HDDT and HDGT. As a final QA check, the VMT for each road speed category and MOBILE5 vehicle class was summed to verify that the total VMT agreed with the total VMT in Table VM-1.

3.46.3   Emission Factors

The emission factors for CO, NO_x, and NMOG, were determined using EPA's MOBILE5 model as documented in Reference 4. This model required information on the following parameters: calendar year, vehicle speeds, temperature, vehicle operating mode, vehicle registration distribution, Reid vapor pressure (RVP), and altitude. For the years 1940, 1950, and 1960, national annual average conditions were used as inputs into MOBILE5 to determine national emission factors for each unique combination of vehicle type, vehicle speed, and altitude.

The earliest calendar year for which on-road vehicle emission factors can be estimated using MOBILE5 is 1960. Therefore, the emission factors for 1940, 1950, and 1960 were all modeled using a calendar year of evaluation of 1960. The use of 1960 as the calendar year for each of these years gives reasonable results since no emission standards were in place before 1960.

Three speeds were modeled in each of the years evaluated. A single speed was selected to represent each of three road classes — urban, rural, and limited access roads. In 1940 and 1950, the speeds modeled to correspond with each of these road classes were 19.6 mph for urban roads, 35 mph for rural roads, and 45 mph for limited access roads. In 1960, the modeled speeds were 19.6 mph for urban roads, 45 mph for rural roads, and 55 mph for limited access roads.

Two sets of temperature data were used in the modeling. For low altitude areas, the average maximum daily temperature modeled was 65°F and the average minimum daily temperature modeled was 41°F. For high altitude areas, the average maximum daily temperature modeled was 62°F and the average minimum daily temperature modeled was 38°F. These temperatures were selected to be representative of national average daily temperature conditions for low and high altitude areas.

In all of the MOBILE5 modeling, the operating mode assumptions of the Federal Test Procedure (FTP) were used. In the FTP operating mode, 20.6 percent of all VMT is accumulated in the cold start mode, 27.3 percent of all VMT is accumulated in the hot start mode, and 52.1 percent of all VMT is accumulated in the hot stabilized mode.

A national registration distribution was developed for 1970 based on the cars and trucks in operation by model year obtained from Reference 2 and on truck sales data from References 2 and 3. This registration distribution was used in determining the emission factors for the years 1940, 1950, and 1960 and is presented in Table 3.46-4.

The gasoline volatility, or Reid vapor pressure (RVP) for the years 1940, 1950, and 1960 was modeled at 10.1 pounds per square inch (psi). Separate emission factors were calculated for high and low altitude areas.

Based on these input values for each year, the MOBILE5 model produced year-specific CO, NO_x, and NMOG emission factors for each combination of vehicle type, road type, and altitude.

The emission factors for PM-10, SO_2, and TSP are presented in Table 3.46-5. The procedure for determining these emission factors is currently unavailable.

3.46.4   Calculation of Emissions

Average national emission factors for CO, NO_x, and NMOG by vehicle type and road type were calculated by weighting the high and low altitude emission factors by the proportion of the VMT estimated for each of these two altitude groups. It was estimated that 93.5 percent of national VMT was accumulated in low altitude areas and the remaining 6.5 percent of VMT was accumulated in high altitude areas. These national average emission factors by vehicle type and road type were then multiplied by the corresponding national VMT by vehicle type and road type to estimate total national annual emissions for CO, NO_x, and NMOG from on-road vehicles in 1940, 1950, and 1960.

The national annual PM-10, SO_2, and TSP emissions were calculated using the total VMT and emission factors by vehicle type as presented in Tables 3.46-1, 3.46-2, 3.46-3 and 3.46-5.

3.46.5   References

1.   *Highway Statistics*. Federal Highway Administration, U.S. Department of Transportation, Washington, DC. Annual.

2.   *AAMA Motor Vehicle Facts and Figures 19xx*. American Automobile Manufacturers Association of the United States, 1620 Eye Street, N.M., Suite 1000, Washington, DC. Annual.

3.   *19xx Market Data Book*. Automotive News. 965 E. Jefferson Ave., Detroit, MI. Annual.

4.   *User's Guide to MOBILE5 (Mobile Source Emissions Model), Chapter 2*. Draft. Office of Mobile Sources, U.S. Environmental Protection Agency, Ann Arbor, MI. December 1992.

Table 3.46-1. 1940 VMT by Road Type

Vehicle Type	VMT (billion miles per year)			
	Limited Access Roads	Urban Roads	Rural Roads	Total VMT
Gasoline				
Passenger Cars	93.4	96.6	59.1	249.1
Light duty Trucks 1	9.8	7.7	8.5	26.0
Light duty Trucks 2	2.5	1.9	2.1	6.5
Heavy duty Trucks	8.5	6.1	5.4	20.0
Motorcycles	0.2	0.1	0.1	0.4
Diesel				
Passenger Cars	0.0	0.0	0.0	0.0
Light Trucks	0.0	0.0	0.0	0.0
Heavy duty Trucks	0.0	0.0	0.0	0.0
Total	**114.4**	**112.4**	**75.2**	**302.0**

Table 3.46-2. 1950 VMT by Road Type

	VMT (billion miles per year)			
Vehicle Type	Limited Access Roads	Urban Roads	Rural Roads	Total VMT
Gasoline				
Passenger Cars	147.0	127.2	87.8	362.0
Light duty Trucks 1	17.1	11.9	14.1	43.1
Light duty Trucks 2	4.3	2.9	3.5	10.7
Heavy duty Trucks	16.8	9.5	11.6	37.9
Motorcycles	0.6	0.6	0.4	1.6
Diesel				
Passenger Cars	0.0	0.0	0.0	0.0
Light Trucks	0.0	0.0	0.0	0.0
Heavy duty Trucks	1.6	0.6	0.7	2.9
Total	**187.4**	**152.7**	**118.1**	**458.2**

Table 3.46-3. 1960 VMT by Road Type

	VMT (billion miles per year)			
Vehicle Type	Limited Access Roads	Urban Roads	Rural Roads	Total VMT
Gasoline				
Passenger Cars	256.8	184.5	144.8	586.1
Light duty Trucks 1	24.5	15.0	19.2	58.7
Light duty Trucks 2	6.1	3.8	4.7	14.6
Heavy duty Trucks	21.7	9.0	12.7	43.4
Motorcycles	1.0	0.6	0.4	2.0
Diesel				
Passenger Cars	0.0	0.0	0.0	0.0
Light Trucks	0.0	0.0	0.0	0.0
Heavy duty Trucks	7.9	2.7	2.3	12.9
Total	**318.0**	**215.6**	**184.1**	**717.7**

Table 3.46-4. National Vehicle Registration Distribution used in Determining Emission Factors for the Years 1940, 1950, and 1960

Number of Years Preceding Current Year	Vehicle Types							
	LDGV	LDGT1	LDGT2	HDGV	LDDV	LDDT	HDDV	MC
-1	0.081	0.085	0.1	0.058	0.081	0.085	0.104	0.133
-2	0.111	0.119	0.122	0.077	0.111	0.119	0.132	0.145
-3	0.105	0.094	0.109	0.071	0.105	0.094	0.11	0.138
-4	0.102	0.093	0.094	0.082	0.102	0.093	0.114	0.116
-5	0.099	0.085	0.086	0.072	0.099	0.085	0.098	0.123
-6	0.096	0.078	0.072	0.073	0.096	0.078	0.085	0.114
-7	0.089	0.073	0.068	0.07	0.089	0.073	0.08	0.069
-8	0.082	0.063	0.058	0.066	0.082	0.063	0.062	0.044
-9	0.068	0.052	0.048	0.061	0.068	0.052	0.048	0.024
-10	0.05	0.04	0.037	0.053	0.05	0.04	0.033	0.009
-11	0.036	0.036	0.034	0.052	0.036	0.036	0.03	0.084
-12	0.024	0.03	0.028	0.042	0.024	0.03	0.025	0.001
-13	0.014	0.025	0.023	0.035	0.014	0.025	0.019	0
-14	0.01	0.024	0.022	0.034	0.01	0.024	0.017	0
-15	0.008	0.02	0.018	0.027	0.008	0.02	0.014	0
-16	0.006	0.02	0.019	0.029	0.006	0.02	0.01	0
-17	0.006	0.016	0.016	0.025	0.006	0.016	0.006	0
-18	0.006	0.018	0.017	0.028	0.006	0.018	0.004	0
-19	0.005	0.013	0.014	0.021	0.005	0.013	0.004	0
-20	0.001	0.003	0.003	0.004	0.001	0.003	0.001	0
-21	0.001	0.003	0.002	0.003	0.001	0.003	0.001	0
-22	0	0.002	0.002	0.003	0	0.002	0.001	0
-23	0	0.002	0.002	0.002	0	0.002	0.001	0
-24	0	0.002	0.001	0.002	0	0.002	0	0
-25	0.001	0.005	0.005	0.009	0.001	0.005	0.001	0

Table 3.46-5. PM-10, TSP, and SO$_2$ On-road Vehicles Emission Factors for 1940, 1950, and 1960

Vehicle Type	PM-10 (lb/thousand VMT)			TSP (lb/thousand VMT)			SO2 (lb/thousand VMT)		
	1940	1950	1960	1940	1950	1960	1940	1950	1960
Gasoline									
Passenger Cars	1.28	1.21	1.42	1.36	1.28	1.5	NA	NA	NA
Light duty Trucks 1	1.3	1.24	1.46	1.38	1.32	1.54	NA	NA	NA
Light duty Trucks 2	1.37	1.27	1.35	1.53	1.41	1.51	NA	NA	NA
Heavy duty Trucks	2.88	2.69	3.15	2.88	2.69	3.15	0.1	0.81	0.54
Motorcycles	0	0	0.77	0	0	0.77	NA	NA	NA
Diesel									
Passenger Cars	NA	NA	NA	NA	NA	NA	NA	NA	NA
Light Trucks	NA	NA	NA	NA	NA	NA	NA	NA	NA
Heavy duty Trucks	NA	6.51	2.39	NA	6.51	2.30	NA	NA	NA

3.47   NON-ROAD ENGINES AND VEHICLES - NON-ROAD GASOLINE ENGINES: 12-01

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source categories.

Tier I Category	Tier II Category	Tier II Subcategory
(12) NON-ROAD ENGINES AND VEHICLES	(01) Non-road Gasoline Engines	Farm Tractors Other Farm Equipment Construction Snowmobiles Small Utility Engines Heavy-duty General Utility Engines Motorcycles

3.47.1   Technical Approach

The CO, NO_x, PM-10, TSP, SO_2, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. For all pollutants except PM-10, the emissions were estimated from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in million gallons and emission factors were expressed in metric pounds/thousand gallons.

The procedures for determining activity indicators and emission factors were used for the years 1940, 1950, and 1960 for CO, NO_x, SO_2, and VOC and for TSP the procedures were used for the years 1940, 1950, 1960, and 1970 through 1992.

The estimation of PM-10 emissions for the years 1940, 1950, and 1960 was based on the relative change in TSP emissions from the 1975 value according to Equation 3.47-1.

$$PM\text{-}10 \ Emissions_{year} \ = \ PM\text{-}10 \ Emissions_{1975} \ \times \ \frac{TSP \ Emissions_{year}}{TSP \ Emissions_{1975}} \qquad \text{(Eq. 3.47-1)}$$

This calculation was used in place of estimating the emissions based on activity indicators and emission factors.

The 1975 PM-10 emissions were determined using the 1975 activity indicators as described in section 3.47.2 and the 1975 PM-10 emission factors. The PM-10 emission factors for all sources except gasoline-powered heavy duty general utility engines were determined from the corresponding TSP emission factors and the particle size distributions obtained from Reference 1a. For snowmobiles and motorcycles, the size distribution for unleaded gasoline was used. For the other gasoline-powered engines, the leaded gasoline size distribution was used. The emission factor for gasoline-powered heavy duty general utility engines was obtained for SCC 2-02-003-01 from Reference 2.

3.47.2 Activity Indicator

The activity indicator for gasoline-powered farm tractors was based on the 1973 gasoline consumption by farm tractors.[3] The 1973 consumption was adjusted to the year under study using the ratio of the quantity of gasoline consumed by all agricultural equipment in 1973 to the quantity in the year under study. These data were obtained from Reference 4a.

$$GC_{Tractor,\ i} = GC_{Tractor,\ 1973} \times \frac{GC_{Agriculture,\ i}}{GC_{Agriculture,\ 1973}}$$

(Eq. 3.47-2)

where: i = year under study
GC = gasoline consumption

The activity indicator for other gasoline-powered farm equipment was based on gasoline consumption. Gasoline consumption by other farm equipment was assumed to be equivalent to 8.52 percent of the quantity of gasoline consumed by farm tractors as determined by the preceding procedure.

The activity indicator for gasoline-powered construction equipment was the total gasoline consumption by construction equipment as reported in Reference 4.

The activity indicator for gasoline-powered snowmobiles was based on the 1973 gasoline consumption by snowmobiles as reported in Reference 3. The 1973 consumption data was adjusted to the year under study using the ratio of the number of snowmobile registrations in 1973 and in the year under study as reported in Reference 5. Equation 3.47-3 summarizes this procedure.

$$GC_{Snowmobiles,\ i} = GC_{Snowmobiles,\ 1973} \times \frac{R_{Snowmobiles,\ i}}{R_{Snowmobiles,\ 1973}}$$

(Eq. 3.47-3)

where: i = year under study
GC = gasoline consumption
R = registration of snowmobiles

The activity indicator for small utility gasoline engines was based on the 1980 gasoline consumption by small engines (533×10^6 gallons). The 1980 consumption data was adjusted to the year under study using the ratio of the number of single unit dwellings in 1980 and in the year under study. The number of single unit dwellings in 1980 was obtained from Reference 6. For the year under study, the number of single unit dwellings was estimated by adjusting the number of single unit dwellings in 1980 with the number of new one-family structures started each year between 1980 and the year under study. The number of new one-family structure started was obtained from Reference 7 for each year. Equation 3.47-4 summarizes this procedure.

$$GC_{SmallEngines,\ i} = \left(533 \times 10^6\ gal\right) \times \frac{Single\ Unit\ Dwellings_i}{Single\ Unit\ Dwellings_{1980}} \qquad \text{(Eq. 3.47-4)}$$

where: i = year under study
        GC = gasoline consumption

The activity indicator for heavy duty general utility gasoline engines was the total gasoline consumed by the industrial commercial category obtained from Reference 4.

The activity indicator for motorcycles was the gasoline consumption calculated from the number of motorcycles, the average annual off-highway mileage traveled, and the median estimated average miles per gallon. The motorcycle population and the off-highway mileage were obtained from Reference 8. The average miles per gallon (MPG) was assumed to be 44.0. Equation 3.47-5 summarizes this calculation.

$$GC_{Motorcycles} = Number\ of\ Motorcycles \times \frac{Off\!-\!Highway\ Mileage}{MPG} \qquad \text{(Eq. 3.47-5)}$$

The activity indicator for gasoline-powered vessels was the total quantity of gasoline consumed by the marine sector (private and commercial) from Reference 4a.

3.47.3   Emission Factor

The emission factors for gasoline-powered farm tractors and other farm equipment were obtained from Reference 1b for all pollutants except PM-10. The VOC emission factors were multiplied by the reactive VOC fraction of 0.918, based on data for profile 90-6021D from Reference 9.

The emission factors for all pollutants, except PM-10, for gasoline construction equipment were the weighted averages of the emission factors for five equipment types. These equipment types and corresponding weighting factors are listed in Table 3.47-1. Emission factors for each equipment type were obtained from Reference 1c. The VOC emission factor was multiplied by the reactive VOC fraction of 0.918. This fraction was based on data for profile 90-6021D from Reference 9.

The emission factors for snowmobiles were obtained from Reference 1d for all pollutants except PM-10. The VOC emission factors were multiplied by the reactive VOC fraction of 0.918, based on data for profile 90-6021D from Reference 9.

The emission factors for all pollutants, except PM-10, for small gasoline utility engines were the weighted averages of the emission factors for five equipment types. These equipment types and corresponding weighting factors are listed in Table 3.47-2. Emission factors for each type were obtained from Reference 1e. The VOC emission factor was multiplied by the reactive VOC fraction of 0.918, based on data for profile 90-6021D from Reference 9.

The emission factors for heavy duty general utility gasoline engines were obtained from Reference 1f for all pollutants except PM-10. The VOC emission factors were multiplied by the reactive VOC fraction of 0.918, based on data for profile 90-6021D from Reference 9.

The emission factors for all pollutants, except PM-10, for motorcycles were obtained from the MOBILE 2 (1978 version) model.[10] Specific parameters used in the model are provided in Table 3.47-3. Resulting emission factors, expressed as grams/VMT were converted to lbs/1,000 gal using the factor 20.8.

The CO, NO_x, SO_2, and VOC emission factors for gasoline-powered vessels were the weighted averages of the emission factors for inboard and outboard motors. The emission factors were obtained from Reference 1g and 1h. Two sets of weighting factors were used for each type of motor. The first weighting factors were the number of registered inboard and outboard motorboats obtained from Reference 11. The second weighting factors accounted for the greater fuel consumption per hour of operation for inboards (2.55) than for outboards (1.55). Equation 3.47-6 summarizes the calculation of the emission factors.

$$ EF = \frac{[(EF_{in} \times R_{in} \times 2.55) + (EF_{out} \times R_{out} \times 1.55)]}{[(R_{in} \times 2.55) + (R_{out} \times 1.55)]} \qquad \text{(Eq. 3.47-6)} $$

where:
EF = emission factor
R = number of registrations
in = inboards
out = outboards

The VOC emission factor was multiplied by the reactive VOC fraction of 0.9172. This fraction was based on data for profile 9-60-21B from Reference 9. The TSP emission factor for gasoline powered vessels was assumed to be zero.

For the years 1940, 1950, and 1960, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier II category.

3.47.4   Control Efficiency

No control efficiencies were applied to the activity data to estimate emissions from nonroad gasoline vehicles and engines.

3.47.5   References

1. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
   a. Volume II, Table 2-20, Appendix L
   b. Volume II, Table II-6-2
   d. Volume II, Table II-8-1
   e. Volume II, Table II-5-1

f.   Volume I, Table 3.3-1
g.   Volume II, Table II-3.5
h.   Volume II, Table II-4.1

2. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listing for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

3. *Exhaust Emissions from Uncontrolled Vehicles and Related Equipment Using Internal Combustion Engines*. U.S. Environmental Protection Agency. Prepared by Southwest Research Institute, San Antonio, TX, under Contract No. EHS-70-108. October 1973.

4. *Highway Statistics*. Federal Highway Administration, U.S. Department of Transportation, Washington, DC. Annual.
    a.   Table MF-24

5. International Snowmobile Industry Association, 7535 Little River Turnpike, Suite 330, Annandale, VA 22003. Contact: Roy Muth (703) 273-9606.

6. *American Housing Survey, Current Housing Reports, Series H-150-83*. Bureau of the Census, U.S. Department of Commerce, Washington DC. Biennual.

7. *Survey of Current Business*. Bureau of Economic Analysis, U.S. Department of Commerce, Washington, DC. Annual.

8. Motorcycle Industry Council, Inc., 19xx Motorcycle Statistical Annual. Costa Mesa, CA. Annual.

9. *Volatile Organic Compound (VOC) Species Data Manual*. EPA-450/4-80-015. U.S. Environmental Protection Agency, Research Triangle Park, NC. July 1980.

10. *Mobile Source Emissions Model (MOBILE2) Version 2*. Office of Mobile Sources, U.S. Environmental Protection Agency, Ann Arbor, MI. 1978.

11. *Boating Registration Statistics*. National Marine Manufacturers Association, 401 N. Michigan Avenue, Suite 1150, Chicago, IL. Annual.

Table 3.47-1. Emission Factor Equipment Types and Weighting Factors for Gasoline Construction Equipment

Equipment Type	Weighting Factor, based on consumption in 1,000 gal/year
Wheel Tractor	94,774
Motor Grader	12,240
Wheel Loader	104,726
Roller	147,439

Table 3.47-2. Emission Factor Equipment Types and Weighting Factors for Gasoline Small Utility Gasoline Engines

Engine Type	Weighting Factor, based on percentage consumption
Wheel Tractor (2-stroke)	0.065
Motor Grader (4-stroke)	0.935

Table 3.47-3. MOBILE 2 (1978 version) Parameters for Calculation of Emission Factors for Motorcycles

Altitude	Low
Speed	19.6 MPH
Ambient Temp.	57°F
Hot Start/Cold Start Percentages	Zero
All other variables	default values

3.48   NON-ROAD ENGINES AND VEHICLES - NON-ROAD DIESEL ENGINES: 12-02

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source category.   The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source categories.

Tier I Category	Tier II Category	Tier II Subcategory
(12) NON-ROAD ENGINES AND VEHICLES	(02) Non-road Diesel Engines	Farm Tractors Other Farm Equipment Heavy-duty General Utility Engines

3.48.1   Technical Approach

The CO, NO_x, PM-10, TSP, SO_2, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. For all pollutants except PM-10, the emissions were estimated from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in million gallons and emission factors were expressed in metric pounds/thousand gallons.

The procedures for determining activity indicators and emission factors were used for the years 1940, 1950, and 1960 for CO, NO_x, SO_2, and VOC. For TSP, the procedures were used for the years 1940, 1950, 1960, and 1970 through 1992.

The estimation of PM-10 emissions for the years 1940, 1950, and 1960 was based on the relative change in TSP emissions from the 1975 value according to Equation 3.48-1.

$$PM\text{-}10\ Emissions_{year}\ =\ PM\text{-}10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}} \qquad \text{(Eq. 3.48-1)}$$

This calculation was used in place of estimating emissions based on activity indicators and emission factors.

The 1975 PM-10 emissions were determined using the 1975 activity indicators as described in section 3.48.2 and the 1975 PM-10 emission factors. The PM-10 emission factors for all sources, except diesel-powered heavy duty general utility engines were determined from the corresponding TSP emission factor and the particle size distribution obtained from Reference 1a. The emission factor for diesel-powered heavy duty general utility engines was obtained from Reference 2 for SCC 2-02-001-02.

3.48.2   Activity Indicator

The activity indicators for diesel farm tractors and other diesel farm equipment were based on the adjusted total sales (or deliveries) of diesel fuel used on farms obtained from Reference 3a or 4a. It was

assumed that 95.5 percent of this quantity was consumed by farm tractors and 4.5 percent was consumed by other farm equipment.

The activity indicator for diesel construction equipment was the adjusted total sales (or deliveries) of off-highway diesel distillate fuel oil for use in construction from Reference 3b or 4b.

The activity indicator for heavy-duty general utility diesel engines was the sum of the adjusted total sales (or deliveries) of off-highway diesel distillate fuel oil for other uses and of diesel for military uses. These data was obtained from Reference 3b or 4b.

3.48.3   Emission Factor

The emission factors for all pollutants except PM-10 for farm diesel tractors and other farm diesel equipment were obtained from Reference 1b. The VOC emission factors were multiplied by the reactive VOC fraction of 0.952, based on data for profile 90-7021 from Reference 5.

For diesel construction equipment, the emission factors for all pollutants except PM-10 were the weighted averages of the emission factors for nine equipment types. These equipment types and the corresponding weighting factors are listed in Table 3.48-1. Emission factors for each equipment type were obtained from Reference 1c. The VOC emission factor was multiplied by the reactive VOC fraction of 0.952, based on data for profile 90-7021 from Reference 5.

The emission factors for heavy duty general utility diesel engines were obtained from Reference 1d for all pollutants except PM-10. The VOC emission factors were multiplied by the reactive VOC fraction of 0.952, based on data for profile 90-7021 from Reference 5.

For the years 1940, 1950, and 1960, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier II category.

3.48.4   Control Efficiency

No control efficiencies were applied to the activity data to estimate emissions from nonroad diesel vehicles and engines

3.48.5   References

1. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
   a.   Volume II, Table 2-2, Appendix L,
   b.   Volume II, Table II-6-2
   c.   Volume II, Table II-7-1
   d.   Volume II, Table 3.3-1

2. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listing for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

3. *Petroleum Marketing Monthly*. DOE/EIA-0380(xx/01). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
   a. Table entitled, "Deliveries for Farm Use: Distillate Fuel Oil and Kerosene"
   b. Table entitled, "Deliveries for Military Use: Distillate Fuel Oil and Residual Fuel Oil; Deliveries for Off-Highway Use: Diesel"

4. *Fuel Oil and Kerosene Sales 19xx*. DOE/EIA-0535(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
   a. Table entitled, "Adjusted Sales for Farm Use: Distillate Fuel Oil and Kerosene."
   b. Table entitled, "Adjusted Sales for Military Use: distillate Fuel Oil and Residual Fuel Oil; Adjusted Sales for Off-Highway Use: Diesel."

5. *Volatile Organic Compound (VOC) Species Data Manual*. EPA-450/4-80-015. U.S. Environmental Protection Agency, Research Triangle Park, NC. July 1980.

Table 3.48-1. Emission Factor Equipment Types and Weighting Factors for Diesel Construction Equipment

Equipment Type	Weighting Factor, based on consumption in 1,000 gal/year
Tracklaying Tractor	912,279
Wheel Tractor	846,035
Wheeled Dozer	47,077
Scraper	621,523
Motor Grader	164,368
Wheeled Loader	753,511
Tracklaying Loader	229,680
Off-Highway Truck	470,550
Roller	30,180

3.49   NON-ROAD ENGINES AND VEHICLES - AIRCRAFT: 12-03

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source category.

Tier I Category	Tier II Category	Tier II Subcategory
(12) NON-ROAD ENGINES AND VEHICLES	(03) Aircraft	FAA Facilities Military Facilities General Aviation

3.49.1   Technical Approach

The CO, NO_x, PM-10, TSP, SO_2, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. For all pollutants except PM-10, the emissions were estimated from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in thousand LTO cycles and emission factors were expressed in metric pounds/LTO cycle.

The procedures for determining activity indicators and emission factors were used for the years 1940, 1950, and 1960 for CO, NO_x, SO_2, and VOC and for TSP the procedures were used for the years 1940, 1950, 1960, and 1970 through 1992.

The estimation of PM-10 emissions for the years 1940, 1950, and 1960 was based on the relative change in TSP emissions from the 1975 value according to Equation 3.49-1.

$$PM\text{-}10 \ Emissions_{year} \ = \ PM\text{-}10 \ Emissions_{1975} \ \times \ \frac{TSP \ Emissions_{year}}{TSP \ Emissions_{1975}} \qquad \text{(Eq. 3.49-1)}$$

This calculation was used in place of estimating PM-10 emissions based on activity indicators and emission factors.

The 1975 PM-10 emissions were determined using the 1975 activity indicators as described in section 3.49.2 and the 1975 PM-10 emission factor obtained from Table 3.1-3 of this report.

3.49.2   Activity Indicator

The activity indicators for commercial, air taxi, general aviation, and military aircraft using Federal Aviation Administration (FAA) facilities were the landings and take-offs (LTOs). The total airport operations reported in Reference 1 for each aircraft category were divided by 2 in order to obtain the number of LTO cycles.

The activity indicator for general aviation aircraft using military facilities was assumed to be a constant 1200 LTOs.

The activity indicator for military aircraft using military facilities was based on the military LTOs at military facilities from the year preceding the year under study. Total military LTOs from the year preceding were calculated as the sum of military LTOs from military facilities and from FAA facilities. Total LTOs were projected to the year of study by using the ratio between total flying hours for active U.S. military aircraft flying in the continental United States for the year under study and for the preceding year. Total flying hours data were obtained from Reference 2. From the resulting total military LTOs for the year under study, military LTOs from FAA facilities were subtracted in order to determine military LTOs from military facilities for the year under study. The procedure for determining the miliary LTOs from FAA facilities was described previously. This overall calculation of the activity indicator is summarized in Equation 3.49-2.

$$MLTO_{MF,\,i} \;=\; \left[(MLTO_{FAA,\,i-1} + MLTO_{MF,\,i-1}) \times \left(\frac{FH_i}{FH_{i-1}} \right) \right] - MLTO_{FAA,\,i} \qquad \text{(Eq. 3.49-2)}$$

where: MLTO = military LTO
MF = military facilities
FAA = FAA facilities
FH = total flying hours
i = year under study

The activity indicator for general aviation aircraft using other facilities was based on the assumption that civil aircraft average 250 LTO cycles per year. Total general aviation LTOs were estimated by multiplying the number of registered civil aircraft, excluding gliders, blimps, and balloons, by the average LTO cycles per year. The number of registered civil aircraft was obtained from Reference 3. From this total was subtracted the general aviation LTOs at FAA facilities and at military facilities. These values were determine using procedures described previously. This calculation is summarized in Equation 3.49-3.

$$GA_{OF} \;=\; (AC \times 250 \; cycles/year) - GA_{FAA} - GA_{MF} \qquad \text{(Eq. 3.49-3)}$$

where: GA = General Aviation LTOs
AC = Number of U.S. registered civil aircraft, excluding gliders, blimps, and balloons
OF = Other Facilities
FAA = FAA Facilities
MF = Military Facilities

3.49.3   Emission Factor

The emission factors for all pollutants except PM-10 for commercial aircraft using FAA facilities were the weighted averages of the emission factors for each commercial aircraft type. These emission factors are presented in Table 3.49-1. The weighting factors were the estimated LTO's for each aircraft type.

In order to estimate the LTO's for each aircraft type, the estimated number of LTOs by aircraft type from the year preceding the year under study were projected to the year under study. This projection was accomplished for each aircraft type using the ratio of the number of aircraft in operation in the year under study to the number in the the preceding year. These values were obtained from Reference 3. The estimated number of LTO's by aircraft type for the preceding year were obtained by using this same methodology on data from the preceding year.

The estimated LTOs by aircraft type for the year under study were normalized to the actual total number of LTO's as reported in Reference 1. These normalized LTOs for each aircraft type were the weighting factor used to calculate the weight average emission factors for commercial aircraft using FAA facilities.

The emission factors for all pollutants except PM-10 for air taxis using FAA facilities were the weighted averages of the emission factors for each air taxi aircraft type.[4] These emission factors are presented in Table 3.49-2. Weighting factors were the estimated number of each air taxi aircraft type as reported in Reference 3.

The emission factors for all pollutants except PM-10 for general aviation aircraft using FAA facilities were the weighted averages of the emission factors for each aviation aircraft type.[4] These emission factors are presented in Table 3.49-3. Weighting factors were the estimated number of flying hours for each aircraft type obtained from Reference 2a. It was assumed that the number of flying hours was proportional to the number of LTO cycles.

The emission factors for all pollutants except PM-10 for military aircraft using FAA facilities were the weighted averages of the emission factors for each military aircraft type.[4] These emission factors are presented in Table 3.48-4. Weighting factors were the estimated number of flying hours for each military aircraft type obtained from Reference 2b. It was assumed that the number of flying hours was proportional to the number of LTO cycles.

The emission factors for all pollutants except PM-10 for military aircraft using military facilities were the same factors as were used for military aircraft using FAA facilities.[4] The emission factors for all pollutants except PM-10 for general aviation aircraft using military facilities were the same factors as were used for general aviation aircraft using FAA facilities.

The emission factors for all pollutants except PM-10 for general aviation aircraft using other facilities were the same factors as were used for general aviation aircraft using FAA facilities.[4]

For the years 1940, 1950, and 1960, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier II category.

3.49.4   Control Efficiency

No control efficiencies were applied to the activity data to estimate emissions from aircraft.

3.49.5   References

1. *FAA Air Traffic Activity FY 19xx*. Federal Aviation Administration, U.S. Department of Transportation, Washington, DC. Annual.
   a.   Table 4, "Airport Operations at Airports with FAA-Operated Traffic Control Towers by Region and by State and Aviation Category."

2. *FAA Aviation Forecasts Fiscal Years 19xx-19xx*. Federal Aviation Administration, U.S. Department of Transportation, Washington, DC. Annual.
   a.   Table 9
   b.   Table 23

3. *Census of U.S. Civil Aircraft, Calendar Year 19xx*. Federal Aviation Administration, U.S. Department of Transportation, Washington, DC. Annual.
   a.   Table 1.1. For Regional, use number of registered aircraft, Table 3.2.

4. *Compilation of Air Pollutant Emission Factors (AP-42), Volume II Mobile Sources, 4th Edition*, Motor Vehicle Emission Laboratory, U.S. Environmental Protection Agency, Ann Arbor, MI. September 1985.

Table 3.49-1. Emission Factors for Commercial Aircraft using FAA Facilities

Commercial Aircraft	Emission Factors (lbs/LTO)				
	CO	NO_x	VOC*	SO_2	TSP
BAC 111	103.63	15.04	71.19	1.7	1.46
Boeing 707	262.64	25.68	214.53	4.28	4.52
Boeing 727	55.95	29.64	13.21	3.27	1.17
Boeing 737	37.3	19.76	8.81	2.18	0.78
Boeing 747	145.1	10.52	42.37	7.55	5.2
L1011	124.7	78.98	71.71	5.3	3.9
DC8	262.64	25.68	214.53	3.27	1.17
DC9	37.3	19.76	8.81	2.18	0.78
DC10	116.88	49.59	46.3	4.98	0.21
General					1.0

* Reactive VOC (already adjusted).

Table 3.49-2. Emission Factors for Air Taxis using FAA Facilities

Air Taxi Aircraft	Emission Factor (lbs/LTO)				
	CO	NO_x	VOC*	SO_2	TSP
Turbojets	50.26	26.63	11.87	2.94	1.05
Turboprops	7.16	0.82	4.99	0.18	0.46
Pistons	100 **	0.6**	3.2**	0.02**	0.3**
General					

* VOC adjustment factor is 0.983 for turbojets and 0.929 for pistons.

**Assumed values used for pistons.

Table 3.49-3. Emission Factors for General Aviation Aircraft using FAA Facilities

General Aviation Aircraft	Emission Factor (lbs/LTO)				
	CO	NO_x	VOC*	SO_2	TSP
Piston:					
Single Engine	11.35	0.02	0.23	0	0.02
Multi-Engine	64.67	0.075	1.35	0	0.02
Turboprop	6.76	0.92	6.46	0.17	0.46
Turbojet	54.36	2.02	6.62	0.74	0.5**
Rotocraft Piston	11.35	0.02	0.23	0	0.02
Rotocraft Turbine	13.33	4.34	2.75	0.26	0.4
General					

* Reactive VOC (already adjusted),

**Particulate emission factor for Turbojet is best guess estimate.

Table 3.49-4. Emission Factors for Military Aircraft using FAA Facilities

Military Aircraft	Emission Factor (lbs/LTO)				
	CO	NO_x	VOC*	SO_2	TSP
Jet (fixed wing)	52.4	9.65	29	1.56	28
Turboprop	23.2	14.1	11.6	0.74	0.46
Piston	53.2	0.29	5.5	0.033	0.28
Helicopter	13.33	4.34	2.75	0.26	0.4
General					

*Reactive VOC (already adjusted).

3.50 NON-ROAD ENGINES AND VEHICLES - MARINE VESSELS: 12-04

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source category.

Tier I Category	Tier II Category	Tier II Subcategory
(12) NON-ROAD ENGINES AND VEHICLES	(04) Marine Vessels	Residual Fuel Oil Diesel Oil Coal

3.50.1 Technical Approach

The CO, NO_x, PM-10, TSP, SO_2, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. For all pollutants except PM-10, the emissions were estimated from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in million gallons and emission factors were expressed in metric pounds/thousand gallons.

The procedures for determining activity indicators and emission factors were used for the years 1940, 1950, and 1960 for CO, NO_x, SO_2, and VOC and for TSP the procedures were used for the years 1940, 1950, 1960, and 1970 through 1992.

The estimation of PM-10 emissions for the years 1940, 1950, and 1960 was based on the relative change in TSP emissions from the 1975 value according to Equation 3.50-1.

$$PM\text{-}10\ Emissions_{year}\ =\ PM\text{-}10\ Emissions_{1975}\ \times\ \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}} \qquad \text{(Eq. 3.50-1)}$$

This calculation was used in place of estimating PM-10 emissions based on activity indicators and emission factors.

The 1975 PM-10 emissions were determined using the 1975 activity indicators as described in section 3.50.2 and the 1975 PM-10 emission factors obtained from Table 3.1-3 of this report.

3.50.2 Activity Indicator

The activity indicator for residual fuel oil was the "adjusted" quantity of residual fuel oil delivered for transportation use, vessel bunkering obtained from Reference 1a or Reference 2a.

The activity indicator for diesel oil was the "adjusted" quantity of distillate fuel oil (for diesel) delivered for transportation use, vessel bunkering obtained from Reference 1a or Reference 2a.

The procedure for determining the activity for the years 1940, 1950, and 1960 is currently unavailable. The activity indicator for coal was assumed to be zero after 1979.

3.50.3   Emission Factor

The emission factors for all pollutants except PM-10 for residual fuel oil were based on the emission factors for residual oil-fired commercial steamships obtained from Reference 3a. The emission factors were presented separately for three modes of operation; hotelling, cruise, and full power. Weighted averages of these emission factors were calculated for each pollutant based on the relative amount of time vessels spend operating under these different modes. It was assumed that 80 percent of the time was spent hotelling and 20 percent was spent under full power.

The VOC emission factor was converted to the reactive VOC emission factor by using the factor for profile 101004 obtained from Reference 4.

The emission factors for all pollutants except PM-10 for diesel oil were weighted averages of the emission factors for diesel-fired vessels operating underway and operating under auxiliary power. Weighting factors were based on the relative amount of time the ships spent operating in these modes: 20 percent under auxiliary power and 80 percent underway. The final VOC emission factor was converted to the reactive VOC emission factor by using the factor for profile 907021 obtained from Reference 4.

The emission factors for diesel-fired vessels under auxiliary power were the averages of the emission factors for diesel-fired vessels operating under auxiliary power at 50 percent load. The emission factors for all pollutants except for TSP were obtained from Reference 3b and were averaged over the four output ratings. The average TSP emission factor was obtained from Reference 3c.

The emission factors for diesel-fired vessels underway were the weighted averages of the emission factors for commercial motorships and distillate oil-fired commercial steamships. The emission factors were weighted by the relative population of motorships and steamships. It was assumed that of the overall fleet of diesel-fired vessels, 75 percent were motorships and 25 percent were steamships.

The emission factors for commercial motorships were the averages of the emission factors for the river, Great Lakes, and coastal waterway classifications. The emission factors for all pollutants except for TSP were obtained from Reference 3d and were averaged over the three waterway classifications. The average TSP emission factor was assumed to be equal to the emission factor railroad locomotive obtained from Reference 3e.

The emission factors for commercial distillate oil-fired steamships were the weighted averages of the emission factors for two modes of operations: hotelling and full power. These emission factors were obtained from Reference 3a. The emission factors were weighted by the relative time the steamship spent operating under these two modes. It was assumed that steamship spent 80 of the time hotelling and 20 percent at full power.

The emission factors for all pollutants for coal combustion by marine vessels after 1979 were assumed to have a value of zero. The procedure for determining the activity for the years 1940, 1950, and 1960 is currently unavailable.

For the years 1940, 1950, and 1960, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier II category.

3.50.4   Control Efficiency

No control efficiencies were applied to the activity data to estimate emissions from marine vessels.

3.50.5   References

1.   *Petroleum Marketing Monthly*. DOE/EIA-0380(xx/01). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
      a.   Table A13 and A14

2.   *Fuel Oil and Kerosene Sales 19xx*. DOE/EIA-0535(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
      a.   Table A13 and A14

3.   *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
      a.   Volume II, Table II-3-2
      b.   Volume II, Table II-3-4
      c.   Volume II, Table 3.3-1
      d.   Volume II, Table II-3-1
      e.   Volume II, Table II-2-1

4.   *Volatile Organic Compound (VOC) Species Data Manual*. EPA-450/4-80-015. U.S. Environmental Protection Agency, Research Triangle Park, NC. July 1980.

3.51   NON-ROAD ENGINES AND VEHICLES - RAILROADS: 12-05

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source category.

Tier I Category	Tier II Category	Tier II Subcategory
(12) NON-ROAD ENGINES AND VEHICLES	(05) Railroads	Diesel Residual Fuel Oil Coal

3.51.1   Technical Approach

The CO, NO_x, PM-10, TSP, SO_2, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. For all pollutants except PM-10, the emissions were estimated from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in million gallons and emission factors were expressed in metric pounds/thousand gallons.

The procedures for determining activity indicators and emission factors were used for the years 1940, 1950, and 1960 for CO, NO_x, SO_2, and VOC and for TSP the procedures were used for the years 1940, 1950, 1960, and 1970 through 1992.

The estimation of PM-10 emissions for the years 1940, 1950, and 1960 was based on the relative change in TSP emissions from the 1975 value according to Equation 3.51-1.

$$PM\text{-}10\ Emissions_{year}\ =\ PM\text{-}10\ Emissions_{1975}\ \times\ \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}} \qquad \text{(Eq. 3.51-1)}$$

This calculation was used in place of estimating emissions based on activity indicators and emission factors.

The 1975 PM-10 emissions were determined using the 1975 activity indicators as described in section 3.51.2 and the 1975 PM-10 emission factors obtained from Table 3.1-3 of this report.

3.51.2   Activity Indicator

The activity indicator for the combustion of diesel fuel by locomotives was the "adjusted" quantity of distillate fuel oil deliveries for transportation use (railroads) obtained from Reference 1 or Reference 2.

The activity indicator for the combustion of residual fuel oil by locomotives was based on the "adjusted" quantity of residual fuel oil sales to the "All Other" end use category from Reference 1 or Reference 2. It was assumed that the ratio of fuel consumption by railroads to the fuel consumption included in the "All Other" end use category (which includes railroads) is 8.83×10^{-4}. Therefore, the activity indicator was the value obtained from Reference 1 or Reference 2 multiplied by 8.83×10^{-4}.

The activity indicator for the combustion of coal was the quantity of U.S. coal distribution by "transportation" obtained from Reference 3a. It was assumed that "transportation" as defined in Reference 3 represented the locomotive category.

3.51.3   Emission Factor

The emission factors for diesel fuel combustion by locomotives were obtained from Reference 4a for all pollutants except PM-10. The VOC emission factor was multiplied by 0.952 to account for the reactive portion.

For the combustion of residual fuel oil, the emission factors for all pollutants except PM-10 and VOC were obtained from Reference 4a. The VOC emission factor was obtained from Reference 4b and was multiplied of 0.952 to account for the reactive portion. The SO_2 factor was multiplied by the sulfur content value of 1.34.

The emission factors for all pollutants except PM-10 for the combustion of coal were obtained from Reference 4c. In this reference, the TSP factor was listed as the spreader stoker emission factor. The SO_2 emission factor was multiplied by a sulfur content value of 2.0.

For the years 1940, 1950, and 1960, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier II category.

3.51.4   Control Efficiency

No control efficiencies were applied to the activity data to estimate emissions from railroads.

3.51.5   References

1. *Petroleum Marketing Monthly*. DOE/EIA-0380(xx/01). Energy Information Administration, U.S. Department of Energy, Washington, DC. January issue.

2. *Fuel Oil and Kerosene Sales 19xx*. DOE/EIA-0535(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.

3. *Coal Distribution January-December 19xx*. DOE/EIA-0125(xx/4Q). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
    a.   Table entitled, "Distribution of U.S. Coal by Origin, Destination, and Consumer"

4. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
    a.   Volume II, Table II-2-1
    b.   Volume I, Table 1.3-1 (Industrial Residual Oil Boilers)
    c.   Volume I, Table 1.1-1 (Bituminous Coal Hand-fired Units)

3.52 MISCELLANEOUS - OTHER COMBUSTION: 14-02

The emissions for this Tier II category were determined by the 1940-1984 Methodology for the following source categories.

Tier I Category	Tier II Category	Tier II Subcategory
(14) MISCELLANEOUS	(02) Other Combustion	Wildfires
		Prescribed Burning
		Agricultural Burning
		Structural Fires
		Coal Refuse Burning

3.52.1 Technical Approach

The CO, NO_x, PM-10, TSP, SO_2, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, activity indicators for wildfires and prescribed burning were expressed in acres and emission factors were expressed in metric pounds/thousand short tons. For the other sources, activity indicators were expressed in thousand short tons and emission factors were expressed in metric pounds/short ton.

The procedures for determining activity indicators and emission factors were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to the Equation 3.52-1.

$$PM\text{-}10\ Emissions_{year} = PM\text{-}10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}} \qquad \text{(Eq. 3.52-1)}$$

This calculation was used in place of estimating the emissions based on activity indicators and emission factors.

3.52.2 Activity Indicator

The activity indicator for wildfires is the sum of protected and unprotected land areas burned for each of the five regions. These regions are defined in Table 3.52-1. The area of protected land burned was obtained from Reference 1. Default values used for the unprotected land area burned are given in Table 3.52-2.

For the years 1978 through 1984, the activity indicator for prescribed burning was the acreage burned in 1978 reported in Reference 2. The data are reported for two regions: Southern and Western. It was assumed that the acreage burned remained constant for the years 1978 through 1984. No procedure for determining the acreage burned for the years prior to 1978 is currently available.

The activity indicator for agricultural burning was based on the total quantity of agricultural products burned in 1974 as reported in Reference 3. Because no data were available after 1974, the activity indicators for this category for the years after 1974 were assumed to be the same as that for 1974.

The activity indicator for structural fires was based on the total number of building fires as reported in Reference 4. It was assumed that 6.8 tons of material is burned for every building fire. Alternatively, an estimate of the quantity of material burned was obtained from Reference 5.

The activity indicator for coal refuse burning was based on the estimated total quantity of coal refuse in 1971 from Reference 6. It was assumed that this quantity had been steadily declining over the period after the report was published. A rough approximation was deemed sufficient.

3.52.3   Emission Factor

The emission factors for wildfires were composed of two factors: fuel loading and pollutant yield. The fuel loading related the area of land burned to the quantity of vegetation consumed by fire. The fuel loading data were specific to five regions of the United States. The States included in each region are listed in Table 3.52-1. The pollutant yield related the amount of a given pollutant emitted to the amount of vegetation consumed by fire. The information on these two factors was obtained from Reference 7a except the pollutant yield for PM-10 which was obtained from Table 3.1-2 of this report.

The emission factors for prescribed fires were composed of two factors: fuel loading and pollutant yield. These factors were defined in the same manner as for the wild fire category. The fuel loading was specific to two regions of the United States. The information on these two factor was obtained from Reference 6, except for the SO_2, NO_x, and PM-10 pollutant yield values. The SO_2 and NO_x pollutant yields were assumed to be the same as the pollutant yields for wildfires and, therefore, were obtained from Reference 7a. The PM-10 pollutant yield was obtained from Table 3.1-3 of this report.

The emission factors for all pollutants except PM-10 for agricultural burning were the average of the emission factors for burning sugar cane and field crops. These emission factors were obtained from Reference 7b, except for the NO_x emission factors which were obtained from Reference 7c. The PM-10 emission factor was obtained from Table 3.1-3 of this report.

The emission factors for all pollutants except PM-10 for structural burning were obtained from Reference 8. These emission factors were for open burning and were adjusted using engineering judgment. The PM-10 emission factor was obtained from Table 3.1-3 of this report.

The emission factors for all pollutants except PM-10 for coal refuse burning were obtained from Reference 9. These emission factors were for open burning and were adjusted using engineering judgment. The PM-10 emission factor was obtained from Table 3.1-3 of this report.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier II category.

3.52.4   Control Efficiency

No control efficiencies were applied to the activity data to estimate emissions from the sources included in this Tier II category.

3.52.5   References

1. *The National Forest Fire Report*. Forest Service, U.S. Department of Agriculture. Annual.

2. *Source Assessment Prescribed Burning*. EPA-600/2-79-019H, U.S. Environmental Protection Agency, Research Triangle Park, NC. 1979.

3. *Emissions Inventory from Forest Wildfires, Forest Managed Burns, and Agricultural Burns*. EPA-450/3-74-062. U.S. Environmental Protection Agency, Research Triangle Park, NC. November 1974.

4. *Statistical Abstract of the United States*. Bureau of the Census, U.S. Department of Commerce, Washington, DC. Annual.

5. National Fire Protection Association, Boston, MA.

6. *Information Circular 8515*. U.S. Bureau of Mines, U.S. Department of the Interior, Washington, DC. 1971.

7. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
    a.   Volume I, Section 11.1
    b.   Volume I, Table 2.4-5

8. *Compilation of Air Pollutant Emission Factors, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. February 1972.

9. *OAQPS Data File on National Emissions*. National Air Data Branch, U.S. Environmental Protection Agency, Research Triangle Park, NC. 1984.

Table 3.52-1. States Comprising Regions for Wild Fires Acreage Burned Information

Rocky Mountain	Pacific	East	North Central	South
Arizona	Alaska	Connecticut	Illinois	Alabama
Colorado	California	Delaware	Indiana	Arkansas
Idaho	Guam	Maine	Iowa	Florida
Kansas	Hawaii	Maryland	Michigan	Georgia
Montana	Oregon	Massachusetts	Minnesota	Kentucky
Nebraska	Washington	New Hampshire	Missouri	Louisiana
Nevada		New Jersey	Ohio	Mississippi
New Mexico		New York	Wisconsin	North Carolina
North Dakota		Pennsylvania		Oklahoma
South Dakota		Rhode Island		South Carolina
Utah		Vermont		Tennessee
Wyoming		West Virginia		Texas
				Virginia

Table 3.52-2. Land Area Burned on Unprotected Lands

Region	Acreage (thousands of acres)
Rocky Mountain	198.1
Pacific	184.8
East	65.1
North Central	296.0
South	1,584.1